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Sustainability of Public Services: Is Outsourcing the Answer?

Antonio Sánchez Soliño

Construction Department, Universidad Politécnica de Madrid, ETS Ingenieros de Caminos, calle Profesor Aranguren s/n, 28040 Madrid, Spain; asanoli@ciccp.es

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Abstract: The outsourcing of public services has acquired a prominent position in the political agenda of many countries in recent decades. This paper contributes an analysis of the outsourcing of a public service under a theoretical framework based on a multitask principal-agent model. For the management of the service, a contract is assumed that includes certain incentives to the contractor linked to the outcomes in two types of activities: the first related to cost saving, and the second related to the improvement of the quality of the service. The main results of the paper show, in the first place, the conditions under which the outsourcing of a public service is economically unfeasible. Additionally, the paper shows that, under perfect information conditions, the optimal incentives include the contractor retaining all the cost savings. On the contrary, under conditions of asymmetric information on the quality of the service, the contract should stipulate a certain distribution of the cost savings between the public authority and the contractor. More in general, the formalization of the model presented in this work can contribute to a better understanding of the role of the contracts, and therefore to their improvement.

Keywords: outsourcing; performance pay; public service; public provision

1. Introduction

The provision of public services, in the context of heavy budget constraints, has been at the center of the political and economic debate in many countries [1]. The growing demand for these services, and the difficulties in financing them, have placed in the foreground the need to increase the efficiency of their provision, leading to an extensive discussion on the different systems of public service management [2]. One of the key elements in this debate, which is the motivation of this work, is the outsourcing of these services, which basically consists in transferring their management to a third party, usually through a contractual relationship. Based on this definition, there is a difference between the outsourcing of public services and their full privatization [3], which implies transfer to the private sector of the ownership of the service itself.

The trend towards outsourcing has been based mainly on the search for alternative formulas for the provision of public services that allow them to maintain their extension (in certain cases their universal coverage) and, at the same time, reduce their cost. The obvious concern, from an economic point of view, is how to achieve this objective without generating unwanted incentives that may have a negative effect on the quality of services [4]. In this context, the model developed in this paper is an attempt to provide a theoretical tool for the analysis of the outsourcing decision, and to identify the sectors of activity in which an outsourced management system has a greater probability of improving the results.

Although there is extensive empirical literature on the outsourcing of public services, theoretical work on outsourcing is important because this empirical literature is often contradictory. It is possible to find opposing conclusions on the same field of application, as Dixit [5] points out regarding outsourcing

educational services, to the point that any author can always defend their own starting position by claiming certain “available empirical evidence”, which may increase the confusion in the discussion. In this regard, the theoretical work can serve to frame and guide the empirical research on the subject.

The economic analysis of the outsourcing of public services has been approached by different authors from different theoretical assumptions. First of all, there is the classic work by Hart et al. [6], which is based on the balance between cost and quality objectives, from an incomplete contracting perspective. In the Hart model, the private contractor has ample scope to make a greater or lesser effort (which is not verifiable) without causing a breach of the contract. The contractor will therefore only make an effort to the extent that they contribute to savings in production costs, unless a renegotiation of the contract enables the contractor to accrue at least part of the benefits of an improvement in the quality of the service.

The Hart model has been revisited by Andersson et al. in a recent paper [7]. According to these authors, the contractual incompleteness in the Hart model excludes the possibility of incentive contracts, which constitutes a significant drawback of the model, given the importance of incentives in the actual practice of contracting.

Other studies focus on the assessment of the quality of public services. Carvalho et al. [8] present a holistic model that takes into account the various relationships between citizens, public organizations and society as a whole. Carvalho et al. state that the assessment of the quality of services, in general, is more complex than that of goods, due to their characteristics of intangibility, inseparability between production and consumption and heterogeneity, among others. In this sense, it should not be forgotten that the measurement of the quality of public services must take into account these characteristics and their multidimensional nature.

From another perspective, Dahlström et al. [9] argue that the potential negative effects of outsourcing can be offset, to a large extent, by establishing appropriate contracts and efficient monitoring of the contractor’s performance; this, in turn, fundamentally depends on the competence of the personnel at the service of the Public Administration.

It is also worth mentioning several theoretical studies on the outsourcing of services in some particular sectors. Regarding public health, Eggleston [10] established a theoretical framework, based on an agency model, which explains the difficulties in establishing an incentive system in this sector. Regarding education, the work by Dixit [5], which is more general in nature, nevertheless includes an interesting application in this field. Dixit points out, among other aspects, the plurality of objectives of the public authority, as well as of stakeholders involved in the educational activity, which makes it difficult to manage them under a contractual scheme. In the field of University education, Phillips et al. [11] point out the limits of the market logic inherent in the outsourcing of services.

In the field of prison management, starting with the theoretical assumptions made by Hart et al. [6] and Hart [12], these authors reveal the inconvenience of completely outsourcing the management of prisons. In the field of transport infrastructures, where outsourcing processes have been introduced in many countries, the works by Iossa and Martimort [13], and Sánchez Soliño [14] can be mentioned.

While the theoretical approach in most of these papers is based on agency models applied to a contractual relationship, in some cases what was studied were the specific motivations within public organizations. It is worth mentioning, for example, the study by Canton [15], who started from the concept of an intrinsic motivation of an agent when performing a given task without any apparent reward other than the actual accomplishment of the task itself. The source of this intrinsic motivation may be, for example, the guiding principles that give rise to a particular institution, or the professionalism of certain workers or managers of public organizations [5].

Burgess and Ratto [16] studied explicit incentive schemes within the public sector that were implemented these past twenty years in the United Kingdom as part of the service modernization agenda in this country. The authors investigated the reasons for the infrequent use of performance-based incentive systems within public organizations. Burgess and Ratto highlight the specificities of the tasks carried out in the public sector: among other aspects, the frequent multiplicity of administrations

involved, the difficulties of measuring and monitoring the activities related to the provision of the service, the difficulty in assessing individual evaluation for a task performed by a team, not to mention the presence of intrinsic motivation, as pointed out by Canton [15]. These characteristics would largely explain that the development of explicit incentive mechanisms is more limited in public organizations than in private firms, as well as the difficulties encountered for their application in the United Kingdom.

In short, both Canton [15] and Burgess and Ratto [16] recognize the existence in certain cases of a mentality or vocation of public service, which makes it unnecessary to have explicit incentives. In fact, in their works they reach the conclusion that, under certain conditions, the implementation of a system of monetary incentives in the public sector can eliminate the intrinsic motivation of the civil servants, thus worsening the results achieved. From this point of view, the widespread absence of a system of explicit incentives in the public sector could indicate an efficient public organization based on the intrinsic motivation of the agents; the alternative explanation would be corporate resistances and interests that maintain important inefficiencies in many public organizations.

Possibly, in most cases there is an intermediate situation between the two explanations. The work presented here starts with the potential of improving many public services by establishing a contractual relationship based on a system of explicit incentives; however, this does not mean denying in full the potential of intrinsic motivation in certain cases. In this way, the intrinsic motivation is present in this paper when considering the public management of the service (without a system of explicit incentives) as an organizational alternative, as opposed to the contractual relation being studied. Public service management would not necessarily result in a near zero effort in the provision of the service, but rather in a certain level that would be considered acceptable.

Finally, outsourcing is not a phenomenon limited only to the public sector but has also been increasingly extended to the private sector. Within the private sector, outsourcing has had a considerable impact in the field of Information Technology (IT) services in particular [17]. Šeba [18] states that decisions about outsourcing follow a similar process regardless of whether the organization adopting them is public or private. Among the most frequent reasons for deciding to outsource, both in the private and in the public sector, this author cites the following: focus on core business, lower costs, lack of competence or experience within the organization itself, quality improvement and flexibility gains.

2. Model Formulation

From a methodological point of view, the model developed in this work takes as a starting point a multitask agency model, following Holmström and Milgrom [19]. This framework is applied to the case of a public authority that decides to cede the management of a particular public service to a third party. However, the methodology used in the present work is different from the one proposed by Holmström and Milgrom by introducing the marginal cost of public resources in the model. This allows for a unique solution of the optimization problem, as explained below.

The main contribution of this work is therefore the specific application of agency theory to the provision of public services and the identification of the key factors on which the viability of outsourcing processes depends on. The role played by the different factors is not intuitive in all cases, as seen in the results of the model (Section 3).

In the model, a given public authority (the principal) proposes to provide a certain public service, for which it is responsible, through the establishment of a contractual relationship with a private company (the agent). The company will be responsible for the management of the service in exchange for a remuneration established in the contract. It is assumed that the service is free for the end users, although most of the conclusions obtained from the model are easily extensible to the case in which the service is paid in part by the users, the public authority fixing the corresponding tariff.

The remuneration of the service established in the contract will depend on the value reached by certain variables used to measure the performance of the contractor, such as the quality of the service. We will assume that the public authority behaves like a benevolent regulator [20], who tries to maximize a social welfare function that will depend, in turn, on the performance of the contractor.

In the model, it is assumed that the public authority is interested in two types of outcomes: the first one (x_1) refers to the result obtained by the contractor in the cost control of the service, and the second refers to the improvement of the quality of the service. In general, the quality of the service will have multiple dimensions, which will be measured by a variety of indicators; however, to make the model manageable we will consider a single integrated variable (x_2) that will measure the quality. Note that the signal about service quality may also be, for example, service demand, if there is a significant relationship between user demand and quality. In some cases, demand can be used as a measure of those dimensions of quality that can be observed by users but cannot be verified by the public authority [21].

The levels of the variables x_1 and x_2 will be related to the respective efforts made by the contractor. However, the latter will not in general be directly verifiable by the public authority, which would base the incentive scheme on the values given by indicators x_1 and x_2 . These variables will in principle be observable and verifiable by the public authority and may be used to determine the remuneration of the contractor. However, these indicators will only give us an approximation of the efforts made, since they will contain a random component. Therefore, the relationships between efforts and indicators would be the following:

$$x_1 = e_1 + \varepsilon_1, \quad (1)$$

$$x_2 = e_2 + \varepsilon_2, \quad (2)$$

In these expressions, e_1 and e_2 represent the contractor's efforts regarding cost control and service quality, respectively, while the variables ε_1 and ε_2 represent a random component in each case. This means that the contractor has a certain level of uncertainty regarding the remuneration to be received, which will not only depend on their efforts, but also on other unforeseeable factors that we group in the mentioned random variables. It is also assumed that e_1 and e_2 must take positive values; the values $e_1 = 0$ and $e_2 = 0$ would mean a fall to levels unacceptable to the public authority and would entail the termination of the contract. Obviously, the variables e_1 and e_2 are purely instrumental in the model, and it is possible to arbitrarily choose the "units" in which the efforts are measured. In this case, it is interesting for the formulation of the model to identify the effort e_1 with the cost savings, in monetary units, that the contractor expects to obtain, whereas for the effort e_2 it is not necessary to define a determined unit of measure.

In the most general case, it can be assumed that the variables ε_1 and ε_2 follow a probabilistic distribution with mean equal to zero and standard deviation equal to σ_1 and σ_2 , respectively, and that both variables are correlated, with a covariance σ_{12} . However, in this general case it is difficult to draw conclusions from the results of the model. On the other hand, it is possible to assume that the error in the measurement of the effort in the control of costs (ε_1) is of an order inferior to ε_2 [7]. In the case of costs, there may be both estimation problems on the part of the agent as well as measurement problems [22], but, predictably, these problems will be limited. The difficulties will be greater in defining an adequate system of quality indicators that can be measured with some precision and used in a contract. Therefore, the analysis will be focused on the error of estimation of the effort in service quality, and it will be assumed that $\sigma_1 = 0$ (and, therefore, $\sigma_{12} = 0$). Note that the conclusions obtained for this particular case may be extended to the case where σ_1 is of an order significantly less than σ_2 . Nevertheless, the results for the general case are also included at the end of Appendix A.

With this approach, the contractor's remuneration (which will be called t) is introduced in the model as a linear system of incentives, taking into account the optimality of such linear systems, as demonstrated by Holmström and Milgrom [23]:

$$t(x_1, x_2) = \alpha + \beta_1 x_1 + \beta_2 x_2, \quad (3)$$

In the particular case described above, $x_1 = e_1$, so the following expression holds:

$$t(x_1, x_2) = \alpha + \beta_1 e_1 + \beta_2 x_2, \quad (4)$$

where α , β_1 and β_2 are the parameters established in the contract, and that the public authority will try to optimize. The parameter α is a fixed payment to the contractor, independent of the efforts made by the latter, while β_1 and β_2 are the parameters that represent the incentives to save costs and to improve quality, respectively.

The contractor's remuneration will therefore be a random variable and its expected value will be:

$$E[t] = \alpha + \beta_1 e_1 + \beta_2 e_2, \quad (5)$$

And its variance will be given by:

$$V[t] = \beta_2^2 \sigma_2^2, \quad (6)$$

Regarding the cost of the service, this will depend on the efforts made by the contractor. Again, in order to advance in the interpretation of the model results, it is necessary to work with a given cost function, under the assumption that it is strictly convex with respect to each of the two variables of effort e_1 and e_2 . A quadratic cost function of the following type will be taken, similar to that used by other authors [5,24]:

$$C(e_1, e_2) = C_0 + e_1^2 + e_2^2 + k e_1 e_2, \quad (7)$$

where C_0 represents a fixed cost, independent of the efforts made, and k is a parameter that can take positive or negative values. This cost function does not include the cost savings generated by the contractor's activity, which will be introduced in the model as a benefit through the function of social welfare.

Note that it is assumed that the efforts made by the contractor, e_1 and e_2 , are not technologically independent, since the marginal cost of each effort also depends on the other effort:

$$C'_1 = 2e_1 + k e_2, \quad (8)$$

$$C'_2 = 2e_2 + k e_1, \quad (9)$$

where C'_1 and C'_2 represent the respective partial derivatives. Note that in the case of a negative k value, the marginal costs of each effort decrease when the other effort increases; this would indicate the presence of complementary efforts. This situation occurs when efforts are made in two tasks such that increasing the effort in one of them improves the performance of the other. On the contrary, in the case of a positive k value, the marginal costs of each effort increase as the level of the other effort increases; this would mean that efforts are substitutes, as would be the case in the model developed in this paper. Indeed, it can be assumed that a greater effort in controlling costs will increase the effort required to increase the quality of the service and vice versa. In this paper, the range of values of the parameter k will be between 0 and 2, where the value $k = 0$ would represent the particular case of independent efforts and the value $k = 2$ would represent the case of perfectly substitute efforts.

The assumption of non-independence of efforts makes the multitask model more complicated than agency models with a single task, or with independent tasks, but greatly extends the explanatory capacity of the model and its possible application to complex situations.

The restrictions imposed by the compatibility of incentives can be obtained from the objective function of the contractor, where the latter will try to optimize the efforts made. It is assumed that the preferences of the contractor are of the mean-variance type [25]:

$$U_r = E[t] - C(e_1, e_2) - r V[t], \quad (10)$$

where U_r is the certainty equivalent of the returns expected by the contractor and r is the parameter representing its attitude toward risk. In this paper, it is assumed that the contractor presents risk aversion, implying a value of r greater than zero.

From this expression, it will be necessary to take into account the restrictions imposed by the compatibility of incentives for the contractor. These restrictions will be given by the following first-order conditions:

$$\frac{\partial Ur}{\partial e_1} = \beta_1 - 2e_1 - ke_2 = 0 \Rightarrow \beta_1 = 2e_1 + ke_2, \quad (11)$$

$$\frac{\partial Ur}{\partial e_2} = \beta_2 - 2e_2 - ke_1 = 0 \Rightarrow \beta_2 = 2e_2 + ke_1, \quad (12)$$

On the other hand, the restriction of participation of the contractor must also be taken into account; the contractor will only sign the contract if its utility is greater than the utility that the contractor receives from not signing the contract. If the utility from not signing the contract is equal to zero, the restriction of participation of the agent will be given by:

$$Ur \geq 0, \quad (13)$$

From here, it is possible to propose the social welfare function to be maximized. This social welfare function will be formed by the social benefits expected from the provision of the service less the total costs incurred by society as a whole to deliver the service, including, *inter alia*, the cost derived from the risk aversion of the contractor. Therefore, the social welfare function will be given by:

$$Ws = S(e_1, e_2) - C(e_1, e_2) - rV[t] - \lambda E[t], \quad (14)$$

where Ws represents the social welfare function that the public authority tries to maximize, and $S(e_1, e_2)$ the social benefit function, which will depend on the efforts made by the contractor. It is assumed that $S'_{ii} > 0$ and $S''_{ii} \leq 0$, that is, function S is increasing and concave with respect to each of the variables. This assumption is normally accepted, independently of the adopted theoretical approach [6,26].

Expression (14), includes the extra cost of public resources, given by the term $\lambda E[t]$, where λ is a parameter for which a value greater than zero is assumed. The value $(1 + \lambda)$ represents the marginal cost of public resources [27], i.e., the disutility for taxpayers of the collection of an additional monetary unit. The value of λ will depend on the degree of distortion introduced by the tax system in the decisions of economic agents and the cost of the tax administration, among other factors. Such a parameter will, therefore, be different for each country, and, in general, the available evidence suggests that a greater value can be expected when the total tax burden is higher [28].

The introduction of a marginal cost of public resources greater than 1 in the model is what guarantees the existence of a unique solution for all the parameters which define the incentives for the contractor. In contrast, a marginal cost of public resources equal to 1 (i.e., a value $\lambda = 0$) would yield a unique solution for the parameters β_1 and β_2 , but the optimization of the social welfare function would be compatible with any value of α above a certain level.

Taking into account Equation (10), expression (14) above can be set as follows:

$$Ws = S(e_1, e_2) - (1 + \lambda) [C(e_1, e_2) + rV[t]] - \lambda Ur, \quad (15)$$

And, finally, substituting some terms for their value, the previous expression can be written in the following way:

$$Ws = S(e_1, e_2) - (1 + \lambda) (C_0 + e_1^2 + e_2^2 + ke_1e_2 + r\beta_2^2\sigma_2^2) - \lambda Ur, \quad (16)$$

From this expression, the optimization problem arises in the following terms:

$$\text{Max}_{(Ur, e_1, e_2, \beta_1, \beta_2)} \{Ws\}, \quad (17)$$

subject to restrictions (11), (12) and (13).

3. Results

The solution to the optimization problem is given by the following optimal values of the parameters that define the incentives to the contractor (see Appendix A):

$$Ur^* = 0, \quad (18)$$

$$\beta_1^* = 1 - \left(\frac{2rk\sigma_2^2}{(1+\lambda)(1+4r\sigma_2^2)} S'_2 \right), \quad (19)$$

$$\beta_2^* = \frac{1}{(1+\lambda)(1+4r\sigma_2^2)} S'_2, \quad (20)$$

In the above equations, S'_2 denotes the value of the marginal social benefit of the contractor's effort on the service quality, at the point corresponding to optimal efforts. Note, on the other hand, that from Equations (5), (10) and (18), it is possible to obtain the optimal value corresponding to the parameter α .

The optimal parameter α^* can take a positive or negative value; a negative value would indicate a fixed payment from the contractor to the Administration, which is perfectly possible. However, it would not make sense to define in the contract a negative incentive to cost saving or quality improvement, so the possibility of negative values for parameters β_1^* and β_2^* is excluded.

In the alternative of public provision, it can be assumed that, in the absence of an explicit incentive system, the public service will be provided at a certain level of performance, represented by minimum efforts e_{1m} and e_{2m} in cost control and quality of service, respectively. Thus, it can be assumed that $e_{1m} > 0$ and $e_{2m} > 0$, despite the aforementioned absence of explicit incentives, due to the intrinsic motivation of public organizations, as described in the Introduction section.

Against the alternative of public provision, an explicit incentive system (as would be the case in an outsourced service) could only be viable (in the sense of providing a greater social welfare) if the contractor applies a greater effort in at least one of the dimensions considered, cost control or service quality. Note that this is a necessary but not sufficient condition to guarantee the viability of the application of the incentive system. Even an increase in efforts in both dimensions does not guarantee the viability of outsourcing, taking into account the introduction of the term related to the risk aversion of the agent in the social welfare function.

On the contrary, if the optimal levels of the efforts made by the agent in both dimensions fall below e_{1m} and e_{2m} , it can be ensured that the explicit incentive system is not viable.

From the formulation obtained for optimal incentives, it is possible to deduce the conditions of non-viability of a system of explicit incentives in certain types of public services. For this purpose, it is necessary to carry out a comparative static study, analyzing the variation of the optimal incentives with respect to the variation of certain parameters. For this study, it is useful to consider, without loss of generality, a linear function of social benefits. In this case S'_2 takes a constant value ($S'_2 = q$) in Equations (19) and (20) above.

In this way and taking into account the assumption of substitute efforts ($k > 0$), it can be deduced that β_1^* decreases when the value of the marginal cost of public resources, $1 + \lambda$, increases. On the other hand, it can be deduced, from the partial derivative of β_1^* with respect to σ_2^2 , that:

$$\text{sgn} \left(\frac{\partial \beta_1^*}{\partial \sigma_2^2} \right) = \text{sgn} \{ - (1 + \lambda) [(1 + 4r\sigma_2^2)2rk - (2rk\sigma_2^2)4r] \} = \text{sgn} [- (1 + \lambda)2rk], \quad (21)$$

Therefore, under the assumption of substitute efforts, the sign of the derivative of β_1^* with respect to σ_2^2 will be negative. An analogous analysis would result in parameter β_1^* decreasing as the contractor risk aversion (r) increases. Finally, an increase in the marginal social benefit of quality (q) implies a decrease in β_1^* .

As for the optimal incentive for service quality (β_2^*), it will decrease as risk aversion, uncertainty in quality control (σ_2^2) or marginal cost of public resources ($1 + \lambda$) increase. On the contrary, an increase in the marginal social benefit (q) causes an increase in β_2^* , as expected.

Table 1 is a summary of the sign of the variation of the optimal incentives to the variations in the value of the parameters included in the previous equations.

Table 1. Sign of the derivatives of the optimal incentives with respect to determined parameters.

	λ	r	σ_2^2	q
β_1^*	+	−	−	−
β_2^*	−	−	−	+

Some of these results are not intuitive. In particular, a greater uncertainty regarding service quality (a higher value of variance σ_2^2) decreases not only the optimal incentive with respect to quality, but also the optimal incentive to cost saving. The economic reason for this is that, given the difficulty of providing the contractor with an incentive to promote service quality, the only way to prevent the outsourcing process from negatively affecting the quality of the service is precisely to reduce the incentive to reduce costs.

In some types of public services, there will be a significant level of uncertainty in the control of many aspects of effort in service quality. In Equations (19) and (20) this translates into a high value of σ_2^2 . Therefore, the existence of uncertainty reduces the potential of incentives to improve social welfare. In particular, the combination of high values of σ_2^2 and the marginal benefit of quality (q) can lead to a negative value of the incentive parameter β_1^* , which makes the incentive system unfeasible, taking into account restrictions (11) and (12) and the impossibility of negative values of incentives and efforts.

From this analysis, the following proposition can be formulated.

Proposition. *In a public service that shows sufficiently high values of, jointly, the uncertainty in the measurement of service quality (σ_2^2) and the marginal social benefit of said quality (q), the outsourcing of the service is economically unfeasible, in the sense that it cannot improve the results obtained under the public provision of the service.*

For the formulation of this proposition it has been assumed that the public management of the service would maintain the internal motivation factors described in the Introduction. This assumption ensures a certain level of cost control and quality in the absence of explicit incentives. However, the above proposition is of general scope, because it is valid for any values of e_{1m} and e_{2m} . In other words, there will be certain public services in which outsourcing will be intrinsically unfeasible, even with a low level of performance under public management.

On the contrary, the viability of the outsourcing of a public service cannot be guaranteed even if the uncertainty about the quality of the service is low or even zero, since such viability will depend on the values of e_{1m} and e_{2m} . However, the probability that the outsourcing of a given service is viable increases as the uncertainty in the quality of the service is reduced. The same statement can be made regarding the risk aversion of the contractor.

4. Discussion

Equations (19) and (20) above allow obtaining the optimal incentives in a contract for the outsourcing of a public service, depending on the particular conditions existing in each case. As can be seen, perfect information conditions (equivalent to entering a value $\sigma_2^2 = 0$ in expressions (19) and (20) above) favor the outsourcing processes, and the following values of the incentive parameters would be obtained:

$$\beta_1^* = 1, \quad (22)$$

$$\beta_2^* = q/1 + \lambda, \quad (23)$$

Thus, the optimal incentives under perfect information conditions include the contractor enjoying total cost savings and an incentive to improve service quality that equals the marginal social benefit weighted by the inverse of the marginal cost of public resources. The value $\beta_1^* = 1$ is the maximum possible value under the assumption of substitute efforts and implies that the maximum of social welfare is reached with the maximum incentive to cost saving.

Normally, this is a situation that does not occur in practice but can be considered close to reality in the field of construction and maintenance of public infrastructure and buildings. In these sectors, there is generally extensive experience in the definition of quality indicators and its control by the Administration [14]. Evidence shows that outsourcing processes have advanced especially in sectors such as roads and other transport infrastructures (railways, ports or airports) and also in the construction and maintenance of facilities such as prisons, hospitals or administrative buildings. Likewise, the outsourcing processes seem especially suitable in local services such as the collection and treatment of urban waste or the water supply, where it is feasible to establish adequate systems of quality indicators.

However, the results obtained also imply that there are many greater difficulties in outsourcing certain essential services (prison management, health services, education, etc.), which are generally still directly carried out by the Administration even in cases where the construction and maintenance of the corresponding facilities have been outsourced. The main reason is that in this type of services it is much more difficult to define and adequately control quality indicators. Precisely one of the major contributions of the model developed in this work is the demonstration that a greater uncertainty regarding service quality (a higher value of variance σ_2^2) decreases not only the optimal incentive with respect to quality (as might be expected), but also the optimal incentive for cost saving, in the presence of substitute efforts. Under conditions of imperfect information, the value obtained for the parameter β_1^* from Equation (19) is less than 1. This implies that, under these conditions, the optimal incentives include a certain distribution, between the public authority and the contractor, of the cost savings obtained.

In these public services, the difficulties in establishing an adequate system of quality indicators are high, and this explains the limited scope of outsourcing processes in these sectors, apart from political or social considerations. However, these difficulties do not justify an *a priori* rejection of outsourcing in all cases, since the potential saving of resources in these sectors are also high [6]. Rather, the cited difficulties indicate the need to increase experience in the development of quality control systems that enable the implementation of outsourcing processes with sufficient guarantees.

These results are in line, in general, with those of other authors. Riess [29] focuses on Public–Private Partnership (PPP) contracts for infrastructure provision. According to this author, PPPs have advantages in infrastructure such as roads, bridges, tunnels, water resources and supply, waste management and accommodation services (schools, hospitals and other public buildings). However, core services in education, health and prisons are weak candidates for PPPs, while railway networks and air traffic control would be in an intermediate situation.

Andersson et al. [7] establish a direct relationship between the difficulty in defining the quality of the services in the contract and the negative effects of outsourcing. Among the most difficult sectors for outsourcing they place prison management, residential youth care and employment placement.

A recent report by the Institute for Government of the UK [30] is more optimistic about the possibility of measuring the provider's performance in services such as public health or prison management. On the contrary, according to this report, a government should not outsource services that are integral to its own purpose or reputation. A good example was the management of the so-called Personal Independence Payment, which is the main benefit in the UK to support people who are disabled. This service was outsourced in 2013, and private providers had among their functions the assessment of the aid claimants. However, the performance of the providers was poor, and the

public authority concluded that outsourcing had failed in its aim, and that assessments should be delivered in-house.

5. Conclusions

The results of this work are asymmetric, in the sense that a general statement about the unfeasibility of outsourcing certain services has been reached. On the contrary, there is no general rule that ensures the economic viability of outsourcing a given service, since such viability will depend on the level of performance under the public provision of the service. Therefore, the decision on the outsourcing of a particular service will require an ad hoc study, which takes into account the actual level of performance under public management.

In any case, this paper identifies the basic factors that determine the optimal incentives in an outsourcing process. These factors are the marginal cost of public resources, the substitutive nature of the efforts made by the contractor, the risk aversion of the contractor, the uncertainty in quality control and the marginal social benefit of service quality. Of these factors, only the reduction in uncertainty in quality control and the reduction in risk aversion unequivocally favor the viability of outsourcing.

Although the outsourcing of a public service is a complex process, which must be approached from different points of view, the advantage of a formalized model such as the one presented in this paper is that it explicitly establishes the relationships between the optimal incentives and the different parameters that determine them. Going one step further, the model can serve as the basis for the development of empirical studies on optimal incentives in outsourcing. In this sense, this work can represent a significant contribution to the improvement of the contracts that regulate the relations between the public authority and the contractors.

Finally, it can be pointed out that the results of this work can be extended to the application of an explicit incentive system within the Administration itself, as opposed to a traditional system based solely on the intrinsic motivation of public organizations. The explicit incentive system, under the public provision of the service, would continue to present the same problems as outsourcing. Therefore, in conditions of high uncertainty about the quality of service and high social marginal benefit of quality, a system of explicit incentives would also be unfeasible within a public organization.

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Appendix A. Solution of the Optimization Problem

As can be seen in Equation (16), the social welfare function is monotonically decreasing with U_r (certainty equivalent of the returns of the contractor), when the condition $\lambda > 0$ is fulfilled, so that social welfare will be maximized when $U_r = 0$. Therefore, the optimization problem can be reduced to:

$$\text{Max}_{(e_1, e_2, \beta_1, \beta_2)} \{S(e_1, e_2) - (1 + \lambda)(C_0 + e_1^2 + e_2^2 + ke_1e_2 + r\beta_2^2\sigma_2^2)\}, \quad (\text{A1})$$

subject to restrictions (11) and (12).

If these restrictions are introduced in the social welfare function, the problem can be formulated in the following terms:

$$\text{Max}_{(e_1, e_2)} \{S(e_1, e_2) - (1 + \lambda)[C_0 + e_1^2 + e_2^2 + ke_1e_2 + (4e_2^2 + k^2e_1^2 + 4ke_1e_2)r\sigma_2^2]\}, \quad (\text{A2})$$

Then, the first-order conditions are the following:

$$S'_1 - (1 + \lambda)(2e_1 + ke_2 + 2k^2r\sigma_2^2e_1 + 4kr\sigma_2^2e_2) = 0, \quad (\text{A3})$$

$$S'_2 - (1 + \lambda)(2e_2 + ke_1 + 8r\sigma_2^2 e_2 + 4kr\sigma_2^2 e_1) = 0, \quad (\text{A4})$$

Or, in matrix form:

$$\begin{pmatrix} 2 + 2k^2 r \sigma_2^2 & k + 4kr\sigma_2^2 \\ k + 4kr\sigma_2^2 & 2 + 8r\sigma_2^2 \end{pmatrix} \begin{pmatrix} e_1^* \\ e_2^* \end{pmatrix} = \frac{1}{1 + \lambda} \begin{pmatrix} S'_1 \\ S'_2 \end{pmatrix} \quad (\text{A5})$$

Taking into account that the marginal social value of cost saving (S'_1) will be equal to the marginal cost of public resources ($1 + \lambda$), the following optimal efforts are obtained:

$$e_1^* = \frac{1}{4 - k^2} \left(2 - \frac{kS'_2}{1 + \lambda} \right), \quad (\text{A6})$$

$$e_2^* = \frac{1}{4 - k^2} \left(\frac{(2 + 2k^2 r \sigma_2^2)S'_2}{(1 + \lambda)(1 + 4r\sigma_2^2)} - k \right), \quad (\text{A7})$$

And, from Equations (11) and (12), the optimal values of the incentive parameters are obtained. Finally, the second-order conditions are the following:

$$S''_{11} - 2(1 + \lambda) < 0, \quad (\text{A8})$$

$$S''_{22} - 2(1 + \lambda) < 0, \quad (\text{A9})$$

Note that, under the initial assumptions regarding the function of social benefits, the sign of these expressions is always negative, which indicates the presence of a maximum.

In the most general case (where $\sigma_1 \neq 0$, $\sigma_2 \neq 0$ and $\sigma_{12} \neq 0$), Equations (1) to (3) of Section 2 above are still applicable. However, Equation (4) does not apply, since now $x_1 \neq e_1$. The expected value of the payment to the agent is still given by Equation (5), but the variance of this remuneration will now be:

$$V[t] = \beta_1^2 \sigma_1^2 + \beta_2^2 \sigma_2^2 + 2\beta_1\beta_2 \sigma_{12}, \quad (\text{A10})$$

The cost function and the restrictions of the model do not vary, but the function to be maximized will now be given by:

$$\text{Max}_{(e_1, e_2, \beta_1, \beta_2)} \{S(e_1, e_2) - (1 + \lambda)(C_0 + e_1^2 + e_2^2 + ke_1e_2 + r\beta_1^2 \sigma_1^2 + r\beta_2^2 \sigma_2^2 + 2r\beta_1\beta_2 \sigma_{12})\}, \quad (\text{A11})$$

subject to restrictions (11) and (12).

The solution to this problem, expressed in matrix form, is given by the following values of the optimal incentive parameters:

$$\begin{pmatrix} \beta_1^* \\ \beta_2^* \end{pmatrix} = \frac{1}{1 + \lambda} \left[\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} + 2r \begin{pmatrix} 2 & k \\ k & 2 \end{pmatrix} \begin{pmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix} \right]^{-1} \begin{pmatrix} S'_1 \\ S'_2 \end{pmatrix} \quad (\text{A12})$$

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