Società italiana di economia pubblica
XVIII CONFERENZA

SERVIZI PUBBLICI.
Nuove tendenze nella regolamentazione, nella produzione e nel finanziamento

Pavia, Università, 14 - 15 settembre 2006

PUBLIC PRODUCTION, CONCESSION OR INSTITUTIONAL PUBLIC PRIVATE PARTNERSHIP IN PUBLIC UTILITIES PROVISION

LORENZO BARDELLI, FABIO FIORILLO, PAOLO POLIDORI

pubblicazione internet realizzata con contributo della COMPAGNIA di San Paolo

Public production, concession or institutional Public Private Partnership in public utilities provision*

Lorenzo Bardelli† Fabio Fiorillo‡ Paolo Polidori§

Pavia, 14 - 15 september
preliminary draft, do not quote

Summary and conclusions

From Sappington-Stiglitz's seminal papers (1987), economic literature investigates on efficiency advantages of privatisation in public utilities supply. This literature focuses the analysis on a trade off between production and allocative efficiency, or between the minimisation of production costs and quality improvements. Theoretical and empirical studies do not reach definitive conclusions about the impact of ownership changes on efficiency. The solution of such trade off depends on how the chain of principal-agent linkages is set (see for a review: Cavaliere and Scabrosetti 2006, Meggison and Netter, 2001; Willner, 2001). European Union seems to have caught these contrasting views and in order to improve efficiency, reducing both public and private failures, it (COM 327/2004) suggests the implementation of different types of public-private partnerships (PPP) that could satisfy different national attitudes in the provision of public utilities. In particular it suggests two kind of PPP: the contractual one, in which production is private and the partnership between the public and the private sector is based only on contractual links; the institutional PPP where public and private partners share the ownership of a firm, constituting a new and different organisation. In our paper we model, in a static context, the outcome of utilities production resulting from three different firm's ownership (here intended as governance structure): a pure public ownership, a regulated private firm (a contractual PPP) and a joint public private ownership (an institutional PPP). Public utility production is characterised not only by a quantitative dimension, but also by a qualitative one, which crucially determines the welfare results. Qualitative improvements are defined in a long-term contract in which the service supplier commits to provide annual quality improvements. The actual annual production of quality improvements depends on production factors (here labor) times their effort parameters, and on an efficiency parameter related to firm governance structure which is associated to ownership's non transferable tacit knowledge; moreover it depends on a random shock. In case of private supply this commitment does suffer from moral hazard, because of hidden information on random shock and on the efficiency level depending on tacit knowledge. Moreover, moral hazard depends on hidden action on the effort which the ownership demands to production factors. When the ownership is, entirely or partially, public we assume that the moral hazard problem disappears. The level of moral hazard is not the only difference among public, private and joint ownership. In effect, the production

*We would like to thank ... . We are also grateful to Lorenzo Robotti and Francesco Venturini ... for their comments. The authors assume full responsibility for all propositions and opinions expressed in the paper.

†Utilitatis. Email: bardelli@proaqua

‡Università di Urbino and OPERA. Email: f.fiorillo@uniurb.it

§Università di Urbino and OPERA. Email: p.polidori@giur.uniurb.it

of quality improvements can be assimilated to an innovation production process. Such a process depends on a complex set of factors among which the tacit knowledge is a crucial one. Following Antonelli (2005) we can define tacit knowledge as the set of information, goals, skills, procedures, cultural environment which characterized an agent and that may not be transferred. This tacit knowledge characterises the particular (private, public or joint) pattern of quality improvements, following Atkinson-Stiglitz's idea on localised technical change (1969). For this reasons when a public and a private partner constitute an institutional PPP the efficiency in producing quality improvements depends on how their tacit knowledge may merge or, in other term, on specific knowledge appropriability. The paper points out that optimal ownership structure depends 1) on the ratio of public on private efficiency level in quality improvements production due to tacit knowledge, 2) on a moral hazard index and 3) on appropriability parameters. Public ownership solution is preferred if the ratio of public on private tacit knowledge is higher than a certain threshold, while private ownership is preferred if this ratio is lower then a second threshold. If such a ratio is between these two thresholds, a joint ownership may be the superior solution if both the moral hazard index and the appropriability parameters are high, otherwise the advantages of an institutional PPP disappear.

Jel Classification: .
Keywords: .

1 The privatisation question: public, private or joint supply of public utilities

In the last 20 years, sales of public owned utilities or the provision through private suppliers have come to account around the world (Oecd, 2003). From Sappington-Stiglitz's seminal papers (1987), economic literature investigates on efficiency advantages of privatisation in public utilities supply. This literature focuses the analysis on a trade off between production and allocative efficiency, or between the minimisation of production costs and quality improvements. The solution of such trade off depends on how the chain of principal-agent linkages is set (Cavaliere, Scabrosetti, 2006; Shirley e Walsh, 2004). Privatisation objectives are multiple, and at times conflicting, and their relative importance has varied across countries, and even within the same country they have changed over time. The privatisation movement has been fueled by the following factors: (a) the emergence of national debt and budget constraints; (b) disillusionment with the generally poor performance of state-owned enterprises; (c) technological changes in some public utility sectors that made monopoly provision of certain goods and services obsolete; (d) globalisation of financial markets and the need to free up companies from the constraints of state ownership in order to access these markets; (e) ideological shifts regarding the appropriate role of the state in the economy.

Among these factors one of the more relevant policy objectives of privatisation movement has been the efficiency and performance of companies. Despite the general support (Megginson e Netter 2001) for the idea that privatisation, followed by competition in the market - where possible - or for the market, should bring about a significant increase in the profitability and efficiency of privatised companies, theoretical and empirical studies do not reach definitive conclusions about the impact of ownership changes on efficiency (Florio 2004).

The privatisation superiority on improving efficiency is particularly robust when the firm operates in a competitive market. On the contrary, in many countries public utilities are natural monopolies operating as privately owned regulated industries, or most commonly, as state-owned monopoly providers of services. In this case, there is same evidence of superior efficiency of public

firms. This superior efficiency increases if we consider social costs (Willner 2001).

In effect, given the nature of these industries, governments have been expected to guarantee adequate provision of these essential services at a reasonable cost to the entire population. This means that governments maintain an ongoing interest in these industries, even after they have been fully sold-off, distinguishing them from sale of assets in the purely commercial and competitive sectors of the economy. It follows that for these reasons privatisation of public utilities is complex and require careful considerations.

European Union seems to have caught these contrasting views and in order to improve efficiency, reducing both public and private failures, it (COM 327/2004) suggests to implement different types of public-private partnerships (PPP) that could satisfy different national attitudes in the provision of public utilities. In particular, it defines two kinds of PPP: the contractual one, in which production is private and the partnership between the public and the private sector is based solely on contractual links; the institutional PPP where public and private partners share the ownership of a firm, constituting a new and different organisation.

The term "purely contractual PPP" refers to a partnership based on contractual links between different players. It covers several contractual types where one or more duties of different magnitude are assigned to a private partner, and that can include the design, funding, execution, renovation or exploitation of a work or a service. A typical model is the "concessive model" characterised by a direct link between the private partner and the final user. The private supplies a service under regulation of the government. The remuneration of the contractor usually comes from a charge levied on the users of the service that is, if necessary, integrated by resources coming from the public authorities. Literature presents a wide variety of studies on this issue, either analysing the contractual links among the players (Laffont e Tirole, 1993), either suggesting the intervention of regulating authorities.

The institutionalised PPP involves the establishment of an independent entity held jointly by the public partner and the private partner. As in the previous case the new institutional body, in many cases with legal personality, has the duty of ensuring the delivery of the given service to the public. An institutionalised PPP can be put in place, either by creating an entity held jointly by the public partner and the private one or by a private partner entering in the ownership of an existing public firm. This form of PPP has been used in particular for administering public services at local level (for example, water supply services or waste collection services). The expected main difference of this form of direct cooperation between the public partner and the private partner, compared to the contractual solution, is that it allows the public partner, through its presence in the body of shareholders and in the decision-making bodies of the joint entity, to maintain a relatively high degree of control over the decision processes. Such a mechanism allows first the public to adapt its decisions over time in the light of circumstances and second, and more important, it enables the public to spread its own experience in running the service while having recourse to the support and the specific skills of the private partner. Apparently the mixed public-private solution seems to have the possibility of developing a governance structure able to integrate the capabilities deriving from different public and private experiences. But under which conditions this solution gives superior outcomes compared to the public or private stand alone options is up to now unknown. The outcome will depends on the possibility of integrating different "problem solving activities involving, to varying degrees, also tacit form of knowledge embodied in individuals and organisational procedures" . A "problem solving activity" can be characterised as a process of irreversible, contingent, dependent and uncertain nature, which generates both technical advance and technological competence of the actors performing it and that also involves specific and uncodified capabilities on the part of the different actors (Cimoli, Dosi, 1994).

Following this idea we model, in a static context, the outcomes of utilities production resulting

from three different firm's ownership (or governance) structure: a pure public ownership, a regulated private firm (a contractual PPP) and a joint public private ownership (an institutional PPP). Public utility production is characterised not only by a quantitative dimension, but also by a qualitative one, which crucially determines the welfare results. Qualitative improvements are defined in a long term contract in which the service supplier commits in providing annual quality improvements. The actual annual production of quality improvements depend on production factors times their effort parameters, and on an efficiency parameter related to firm structure of governance which is associated to ownership's non transferable tacit knowledge. Moreover it depends on a random shock, in case of private supply this commitment does suffer from moral hazard, because of hidden information on random shocks and on the efficiency level depending on tacit knowledge. Moreover moral hazard depends on hidden action on the effort which the ownership demands to production factors. When the ownership is, entirely or partially, public we assume that the moral hazard problem disappears. The presence of a public partner in the governance structure of a mixed enterprise could mitigate asymmetric information problems that are hampering the regulation of private firm[1].

The level of moral hazard is not the only difference among public, private and joint ownership. In effect, the production of quality improvements can be assimilated to an innovation production process. Such a process depends on a complex set of factors among which the tacit knowledge is a crucial one. Following Antonelli (2005) we can define tacit knowledge as the set of information, goals, skills, procedures, cultural environment which characterized an agent and that may not be transferred. This tacit knowledge characterises the particular (private, public or joint) pattern of quality improvements, following Atkinson-Stiglitz's idea on localised technical change (1969). For this reasons when a public and a private partner constitute an institutional PPP the efficiency in producing quality improvements depends on how their tacit knowledge may merge or, in other term, on specific knowledge appropriability[2]. The paper points out that optimal ownership structure depends 1) on the ratio of public on private efficiency level in quality improvements production due to tacit knowledge, 2) on a moral hazard index and 3) on appropriability parameters. Public ownership solution is preferred if the ratio of public on private tacit knowledge is higher than a certain threshold, while private ownership is preferred if this ratio is lower then a second threshold. If such a ratio is between these two thresholds, a joint ownership may be the superior solution if both the moral hazard index and the appropriability parameters are high, otherwise the advantages of an institutional PPP disappear.

2 The model

Before describing how to choose among production of public utilities with a public, a private or a mixed firm, we have to describe briefly the production or supply function. In particular we assume that the supply of public services has two dimensions: a quantitative one and a qualitative one. We focus our analysis only on the latter dimension, assuming that in each period θ quality improvements are produced. Let us assume that p_θ is the price of a "unit"of quality improvement. Thus assuming full recovery cost the price of the service is:

$$P = c(w) + \frac{1}{N} p_\theta \overline{\theta_i} + C \quad \text{with} \quad i = G, F, M \tag{2.1}$$

[1]Furthermore, Perotti (1995) adds that partial state ownership can stabilized investors expectation and serve as a credible signal that the state will not adopt vindictive policy after privatization.

[2]With the word appropriability we enfasize the role of the learning process required to capture the knowledge of the partner, this learning process depends on time, on working together and other uncodifiable factors. This learning process is not required if we have codified transferable knowledge.

where $c(w) = \eta w$ is the cost for the production of quantity which depends on the normal (reservation) wage w which pays the employment and on the inverse of labor productivity η. N is the number of citizens that are using the service, for simplicity $N = 1$. C is the per unit annual cost of infrastructure and network to produce and distribute the service, for simplicity we assume $C = 0$.

We may consider the production of service as a long term contract in which a principal (the government) and an agent (the firm i, public $i = G$ or private $i = F$ or PPP $i = M$) agree on producing an average quality (or investment) improvement, for which the government (citizens) always pays to firm $p_\theta \overline{\theta_i}$ even if the actual value of θ_i is different. Thus $\overline{\theta_i}$ is the average quality improvement (or investment) which the firm promises to produce during each period; it must be stressed that this quality can be different from the actual average quality ($\widehat{\theta_i}$) that the firm will produce if moral hazard is possible. Note that $\theta_G = \theta_F = \theta_M$ means that a public firm, a private and a mixed one produce in the same period the same number of qualitative improvements "units", not the same improvements; in effect we assume that quality improvements follows a localised technological pattern which differs depending on the composition of firm board or for simplicity on the ownership of the firms.

Let us assume the production of a quality improvement depends on a stochastic variable and its outcome cannot be forecast, such a long term contract acts as an insurance for firms[3], in effect the production function of θ_i is:

$$\theta_i = (1 + \gamma) h_i (s_i S_i)^\phi \quad \text{with} \quad i = G, F, M \tag{2.2}$$

The production of a quality improvement (equation 2.2) depends on an efficiency parameter h_i, this parameter depends on the stock of specific (tacit) knowledge which characterises the ownership of firm. Thus if $h_G = h_F = h_M$ a public, a private and a mixed firm have the same efficiency parameter in producing quality but the quality improvements patterns differ among firms. Moreover the production of quality depends on the efficiency units of employment $s_i S_i$ where s_i is the effort of each worker and S_i the labor employed in research of quality, and on a stochastic variable γ whose mean is $E(\gamma) = 0$; for simplicity let us assume that γ is uniformly distributed between $-a$ and a with $0 < a < 1$.

Since the firm signs a long term contract for producing quality improvements, it can declare an efficiency $H_i = h_i(1 + k_i)$. This is equivalent to sign a contract where the declared long term quality improvements supply, depending on normal effort s_0, is:

$$\overline{\theta_i} = h_i (1 + k_i) (s_0 S)^\phi \tag{2.3}$$

while the minimum supply accepted by government must be

$$\widetilde{\theta_i} = B_i \overline{\theta_i} = B h_i (1 + k_i) (s_0 S)^\phi \text{ with } B_i \leq 1 \tag{2.4}$$

where B_i is the possibility which government leaves to firms to produce a quality improvements below the declared quality. In effect, assuming long term contract in the production of public services, government can set a minimum production of quality, if the actual quality is lower than the minimum the contract can be broken.

If the government is represented in the firm board, because it has the ownership of the firm (full or partial), firm must declare the real efficiency, so $k_G = 0$; we assume that $B_G = 1 - a$, then the firm can reach its real minimum, the same assumption will be made for a mixed firm in the next section. If the firm is private, it can shirk; let us assume that $B = 1$, hence the declared quality must be also the minimum one.

[3]It is easy to show that if ownership is risk adverse, ownership chooses a long term contract.

Generally speaking, the cash flow to maximise for calculating the supply curve is:

$$\underset{S,k_i}{Max}\ \Pi(S,k_i) = p_\theta \overline{\theta_i} - E(s_0 + ds)S \tag{2.5}$$

If firm is public, $k_G = 0$, the only variable to choose is S_G, thus:

$$S_G^* = (\phi p_\theta h_G)^{\frac{1}{1-\phi}} \tag{2.6}$$

$$\widehat{\theta_G^*} = h_G^{\frac{1}{1-\phi}} (\phi p_\theta)^{\frac{\phi}{1-\phi}} \tag{2.7}$$

$$\Pi_G^* = (1-\phi) p_\theta \widehat{\theta_G^*} \tag{2.8}$$

equation 2.7 is the supply function of θ for public firm.

If firm is private, it maximises the expected cash flow, considering that the contracted quality is also the minimum quality declared, to fulfill the contract, a private firm should ask for an overtime effort to its workers[4], otherwise when the production of new quality θ is lower than the contracted minimum $\widetilde{\theta_F} = \overline{\theta_F}$, the contract can be broken. Thus the following condition must hold:

$$\theta = (1+\gamma) h_F (sS)^\phi \geq \widetilde{\theta_F} = \overline{\theta_F} = h_F (1+k_F) S^\phi \tag{2.9}$$

When condition 2.9 does not hold, ownership asks to workers for an overtime effort for equalising θ and $\widetilde{\theta_F}$. Thus maximising the profit on respect to S_F and k_F, we may calculate the optimal solution[5]:

$$k_F^* = a \tag{2.10}$$

$$S_F^* = (\phi p_\theta h_F)^{\frac{1}{1-\phi}} \left[\frac{1-\phi}{\phi} \frac{2a}{\left(\frac{1+a}{1-a}\right)^{\frac{1-\phi}{\phi}} - 1} \right]^{\frac{1}{1-\phi}} \tag{2.11}$$

Because of its informative advantage

Proposition 2.1 *Private firm always cheats and declare the maximum, not the average, efficiency it can reach. The convenience of cheating is increasing in the magnitude of this advantage, in effect the optimal level of cheating k_F^* increases with a or with the variance of γ. Moreover, it will supply always the declared average production $\widehat{\theta_F}^* = \overline{\theta_F}^*$.*

making some algebra $\Pi_F^* = (1-\phi) p_\theta \widehat{\theta_F}^*$, while recalling the previous result $\Pi_G^* = (1-\phi) p_\theta \widehat{\theta_G}^*$.

Proposition 2.2 *If a private firm and a public one have the same efficiency parameters ($h_F = h_G$), the average quality produced by the private is always lower than the one produced by the public one ($\widehat{\theta_F}^* < \widehat{\theta_G}^*$), moreover the efficiency of a private firm in producing quality is decreasing with the variance of the shocks (a).*

Moral hazard has two opposite effects, from one side the use of overtime effort increases the quality produced, on the other side the increasing in the wage reduces the employment, proposition 2.2 states that the overall effects is negative on production of quality and on firm profit, thus moral hazard leads to a loss of efficiency in producing quality improvements.

[4]The alternative of increasing temporary the labor force is rule out since government can monitor the employment level but not the effort of workers, thus it uses the employment devoted to quantity as a signal to monitor the behavior of the firm, for this reason firm is obliged not to change the employment.

[5]In the appendix the algebra.

3 Institutional PPP

In our analysis we assume that the better way to produce services is the way which shows the greatest quality improvements[6]. Moreover we analyse how quality is produced by a pure public or a pure private firm: the quality produced by a public firm is

$$\widehat{\theta_G} = (\phi p_\theta)^{\frac{\phi}{1-\phi}} h_G^{\frac{1}{1-\phi}} \text{ (equation 2.7)},$$

from propositions 2.1 and 2.2 the quality produced by a private firm depends on the uncertainty of shocks, thus

$$\widehat{\theta_F} = (\phi p_\theta)^{\frac{\phi}{1-\phi}} h_F^{\frac{1}{1-\phi}} (1-\beta(a))^{\frac{1}{1-\phi}}$$

$$\text{where } 0 \leq \beta(a) \leq 1 \ , \ \ \beta(a=0) = 0 \text{ and } \beta(a=1) = 1.$$

$\beta(a)$ can be considered as a loss of efficiency due to moral hazard.

We have to investigate how quality is produced by a mixed firm. In a mixed public-private firm we can assume that the level of h_M is known by both partners and each partner knows the efficiency parameter of each other without costs, or more precisely that private partner does not cheat on it, thus $S_M^* = (\phi p_\theta h_M)^{\frac{1}{1-\phi}}$, $\widehat{\theta_M^*} = h_M^{\frac{1}{1-\phi}} (\phi p_\theta)^{\frac{\phi}{1-\phi}}$ and $\Pi_M^* = (1-\phi) p_\theta \widehat{\theta_M^*}$. Following the suggestion of EU, institutional PPP is a way to internalise a regulating authority in the firm, since a member of government is in the board because it has the partial ownership of the firm. Thus for simplicity we assume that in PPP both partners know their efficiency parameters reciprocally, no moral hazard is possible. What is interesting here is that such parameters cannot simply be added, thus $h_M \neq h_G + h_F$, in effect the impact of tacit knowledge in quality improvements depends on how the two knowledge stocks merge together.

What we have to describe is how to calculate the impact on quality improvements (h_M) coming from a merging of competences. In effect, we assume that the pattern of quality improvement chosen by a public and a private firm are different since they corresponds to different tacit knowledge[7].

Analytically we have to describe the merging function as:

$$h_M = K(h_G, h_F), \quad 0 < \frac{\partial h_M}{\partial h_F} < 1, \, 0 < \frac{\partial h_M}{\partial h_G} < 1 \tag{3.1}$$

We may consider $b_i = \frac{\partial h_M}{\partial h_i}$ as a marginal appropriability of PPP on the knowledge of partner i, this merging depends on several factors: negatively on the internal burocracy which could make the merging less easy, positively on the complementarity of competences and so on the possibility of separating the production tasks between the two partners, negatively on the number of overlapping (duplicate) information. Moreover it depends on costs to evaluate several potential partners[8].

[6] Actually, the decision on producing public service with a public, a private or a mixed firm depends on several other factors, in particular this decision can be described as a game between government which has to decide for a complete or a partial privatization and a firm which may participate to the auction for service assignment or may postpone this participation. The solution of this game permits to set the share of privatisazion or the rental to ask to private firm. With some assumptions on the game structure, on the concession length, on interest rate, on some parameters, we may define as equivalent governance structures the ones which produce the same average quality improvements. Thus the governance structure resulting from the nash equilibrium depends on the ownership structure which produces the highest quality improvements. See the appendix for details.

[7] This idea is not different from the one expressed by Atkinson and Stiglitz(1969).

[8] Or on costs of design the right scheme of incentives for selecting the right partner.

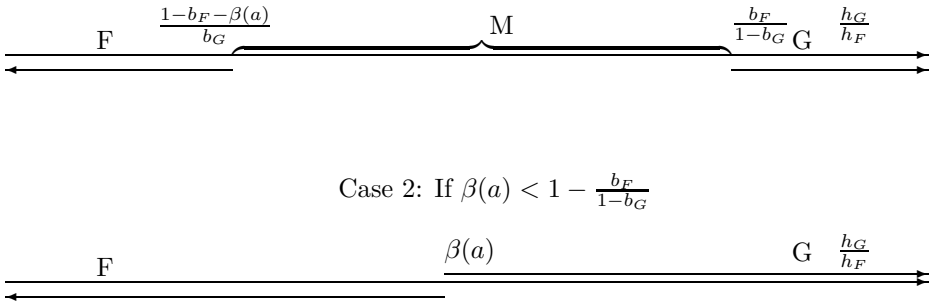

Figure 1: Scope for institutional PPP

Linearizing 3.1, we can simplify the equation 3.1 as:

$$h_M = b_G h_G + b_F h_F$$

thus we can consider constant the appropriability parameters $\left(\frac{\partial h_M}{\partial h_F} = b_F \text{ and } \frac{\partial h_M}{\partial h_G} = b_G\right)$.

Proposition 3.1 *If the moral hazard inefficiency index ($\beta(a)$) and the appropriability parameters are high, there are two thresholds $\delta_F = \frac{1-b_F-\beta(a)}{b_G}$ and $\delta_G = \frac{b_F}{1-b_G}$ for which:*

1. *If $\frac{h_G}{h_F} < \delta_F$ a private firm is preferred.*
2. *If $\delta_F < \frac{h_G}{h_F} < \delta_G$ a mixed firm is preferred.*
3. *If $\frac{h_G}{h_F} > \delta_G$ a public firm is preferred.*

If the above condition does not hold, i.e with low moral hazard index and low appropriability parameters, mixed firm is never preferred and

1. *If $\frac{h_G}{h_F} < \beta(a)$ a private firm is preferred.*
2. *If $\frac{h_G}{h_F} > \beta(a)$ a public firm is preferred.*

Proof. See the appendix. ■

A The algebra

The profit maximisation leads to:

$$S_G = \left[\frac{\phi p_\theta h_G s^\phi}{p_S}\right]^{\frac{1}{1-\phi}} = \frac{1}{s}\left(\phi p_\theta h_G \frac{s}{p_S}\right)^{\frac{1}{1-\phi}} \tag{A.1}$$

If we assume that pS compensate exactly the reservation wage equal to $s_0 + ds$, where ds is the overtime effort and the normal effort is $s_0 = 1$, thus $pS = 1 + ds$, it is easy to demonstrate that neither the production of quality nor the wage bill depend on the effort level[9] thus public firm have no reason to pay overtime[10]. Therefore equations 2.6, 2.7 and 2.8 can be calculated.

When production is private, the condition 2.9 can not hold, in this case ownership asks to workers for an overtime effort for equalising θ and $\widetilde{\theta_F}$. Hence:

$$ds = \begin{cases} 0 & \text{if} \quad \gamma \geq (1+k_F) - 1 \\ \left(\frac{1+k_F}{1+\gamma}\right)^{\frac{1}{\phi}} - 1 & \text{if} \quad \gamma < (1+k_F) - 1 \end{cases} \tag{A.2}$$

Therefore the average overtime effort is

$$\begin{aligned} E(ds) &= \int_{-a}^{(1+k_F)-1} \left[\left(\frac{(1+k_F)}{1+\gamma}\right)^{\frac{1}{\phi}} - 1\right] \frac{1}{2a} d\gamma \\ &+ \int_{(1+k_F)-1}^{a} 0 \frac{1}{2a} d\gamma \\ &= \frac{1}{2}\frac{1-a}{a} \frac{\phi\left(\frac{1+k_F}{1-a}\right)^{\frac{1}{\phi}} - \left[\left(\frac{1+k_F}{1-a}\right) + \phi - 1\right]}{1-\phi} \end{aligned} \tag{A.3}$$

Substituting equations A.3 and 2.4 in 2.5 for $i = F$ and maximising we obtain:
Equation 2.5 for $i = F$ is

$$\Pi(S, k_F) = p\theta\left(\left(1+k_F\right) h_F S^\phi\right) - \left(1 + \frac{1}{2}\frac{1-a}{a}\frac{\phi\left(\frac{1+k_F}{1-a}\right)^{\frac{1}{\phi}} - \left[\left(\frac{1+k_F}{1-a}\right) + \phi - 1\right]}{1-\phi}\right) S \tag{A.4}$$

[9] The wage bill is

$$p_S S = \frac{p_S}{s}\left(\phi p_\theta h_i \frac{s}{p_S}\right)^{\frac{1}{1-\phi}} = \left(\phi p_\theta h_i\right)^{\frac{1}{1-\phi}}$$

and the supplied quality is

$$\widehat{\theta_G} = h_G \left(\phi p_\theta h_i\right)^{\frac{\phi}{1-\phi}} = h_G^{\frac{\phi}{1-\phi}} \left(\phi p_\theta\right)^{\frac{\phi}{1-\phi}}$$

which do not depend on the effort.

[10] In general this is true when $k_i = 0$.

the FOCs are:

$$\begin{aligned}
\frac{\partial}{\partial S}\Pi(S,k) &= 0 \\
\Rightarrow \phi p\theta\,(1+k)\,hS^{\phi-1} &= 1+\frac{1}{2}\frac{1-a}{a}\frac{\phi\left(\frac{1+k_F}{1-a}\right)^{\frac{1}{\phi}}-\left[\left(\frac{1+k_F}{1-a}\right)+\phi-1\right]}{1-\phi} \qquad \text{(A.5)} \\
\frac{\partial}{\partial k}\Pi(S,k) &= 0 \\
\Rightarrow p\theta(1+k_F)hS^{\phi} &= \frac{1}{2}\frac{1-a}{a}\frac{\left(\frac{1+k_F}{1-a}\right)^{\frac{1}{\phi}}-\left(\frac{1+k_F}{1-a}\right)}{1-\phi}S \qquad \text{(A.6)}
\end{aligned}$$

substituting A.6 in A.5 we obtain the equilibrium value of k_F^* (equation 2.10) and S_F^* (equation 2.11).

$$\begin{aligned}
k_F^* &= a \\
S_F^* &= (\phi p_\theta h_F)^{\frac{1}{1-\phi}}\left[\frac{1-\phi}{\phi}\frac{2a}{\left(\frac{1+a}{1-a}\right)^{\frac{1-\phi}{\phi}}-1}\right]^{\frac{1}{1-\phi}}
\end{aligned}$$

The SOCs are:

$$\frac{\partial^2}{\partial S^2}\Pi(S,k) = p\theta\,(1+k)\,hS^{\phi}\frac{\phi^2}{S^2}-p\theta\,(1+k)\,hS^{\phi}\frac{\phi}{S^2} \qquad \text{(A.7)}$$

$$\frac{\partial^2}{\partial S\partial k}\Pi(S,k) = p\theta hS^{\phi}\frac{\phi}{S}-\frac{1}{2}\frac{1-a}{a}\frac{\frac{\left(\frac{1+k}{1-a}\right)^{\frac{1}{\phi}}}{1+k}-\frac{1}{1-a}}{1-\phi} \qquad \text{(A.8)}$$

$$\frac{\partial^2}{\partial k^2}\Pi(S,k) = \frac{-1}{2}\frac{1-a}{a}\frac{\frac{\left(\frac{1+k}{1-a}\right)^{\frac{1}{\phi}}}{\phi(1+k)^2}-\frac{\left(\frac{1+k}{1-a}\right)^{\frac{1}{\phi}}}{(1+k)^2}}{1-\phi}S \qquad \text{(A.9)}$$

Calculating the sign of SOCs in the equilibrium values, we have $\frac{\partial^2}{\partial S^2}\Pi(S,k)<0$ $\frac{\partial^2}{\partial S\partial k}\Pi(S,k)<0$ $\frac{\partial^2}{\partial k^2}\Pi(S,k)<0$ and a negative defined Jacobian matrix. Substituting 2.10 and 2.11 in A.4 and in A.12:

From equations 2.3, 2.10 and 2.11, we can calculate the optimal quality declaration $\overline{\theta_F}^*$

$$\overline{\theta_F}^* = (h_F)^{\frac{1}{1-\phi}}(\phi p_\theta)^{\frac{\phi}{1-\phi}}\left[\frac{1-\phi}{\phi}\frac{2a}{1-\left(\frac{1-a}{1+a}\right)^{\frac{1-\phi}{\phi}}}\right]^{\frac{\phi}{1-\phi}}(1-a) \qquad \text{(A.10)}$$

and A.2, we may calculate the actual production of quality improvements:

$$\theta = \begin{cases} (1+\gamma)\,h_F(S_F^*)^{\phi} & \text{if} \quad \gamma \geq (1+k_F^*)-1 \\ \overline{\theta_F}^* & \text{if} \quad \gamma < (1+k_F^*)-1 \end{cases} \qquad \text{(A.11)}$$

since $1+k_F^*-1=a$, then the average production of quality is:

$$\widehat{\theta_F}^* = \overline{\theta_F}^* \qquad \text{(A.12)}$$

$$\Pi_F^* = \underset{S,k_F}{Max}\,\Pi(S_F^*, k_F^*) = \left((1-\phi)\,p\theta h_F\right)^{\frac{1}{1-\phi}} \left[\frac{2a}{1-\left(\frac{1-a}{1+a}\right)^{\frac{1-\phi}{\phi}}}\right]^{\left(\frac{\phi}{1-\phi}\right)} (1-a) \tag{A.13}$$

and

$$\widehat{\theta_F}^* = \overline{\theta_F}^* = h_F^{\frac{1}{1-\phi}} \left((1-\phi)p_\theta\right)^{\frac{\phi}{1-\phi}} \left[\frac{2a}{1-\left(\frac{1-a}{1+a}\right)^{\frac{1-\phi}{\phi}}}\right]^{\frac{\phi}{1-\phi}} (1-a) \tag{A.14}$$

Thus

$$\Pi_F^* = (1-\phi)\,p\theta\widehat{\theta_F^*} \tag{A.15}$$

while, from equation 2.8

$$\Pi_G^* = (1-\phi)\,p\theta\widehat{\theta_G^*} \tag{A.16}$$

A.1 Proof of proposition 2.2

Since

$$\widehat{\theta_F}^* = h_F^{\frac{1}{1-\phi}} \left(\phi p_\theta\right)^{\frac{\phi}{1-\phi}} \left[\frac{1-\phi}{\phi}\frac{2a}{1-\left(\frac{1-a}{1+a}\right)^{\frac{1-\phi}{\phi}}}\right]^{\frac{\phi}{1-\phi}} (1-a) \tag{A.17}$$

proposition 2.2 is demonstrated if

$$A(a,\phi) = \left[\frac{1-\phi}{\phi}\frac{2a}{1-\left(\frac{1-a}{1+a}\right)^{\frac{1-\phi}{\phi}}}\right]^{\frac{\phi}{1-\phi}} (1-a) \leq 1 \tag{A.18}$$

$$\text{and} \quad \frac{\partial A(a,\phi)}{\partial a} < 0 \tag{A.19}$$

It can be demonstrated that

$$\lim_{a\to 0^+} A(a,\phi) = 1 \tag{A.20}$$

$$\lim_{a\to 1^-} A(a,\phi) = 0 \tag{A.21}$$

$$\tag{A.22}$$

moreover since signum $\left(\frac{\partial A(a,\phi)}{\partial a}\right)$ = signum $\left(\frac{\partial \ln A(a,\phi)}{\partial a}\right)$

$$\frac{\partial \ln A(a,\phi)}{\partial a} = (a+\phi)\cdot \frac{\left(\frac{\phi-a}{\phi+a}\right) - \left(\frac{1-a}{1+a}\right)^{\frac{1}{\phi}}}{(1-\phi)\cdot a\cdot\left[1-\left(\frac{1-a}{a+1}\right)^{\frac{-(\phi-1)}{\phi}}\right]\cdot(1-a)} \tag{A.23}$$

if $a \geq \phi$ then $\frac{\partial \ln A(a,\phi)}{\partial a} < 0$, if $a < \phi$ the signum of $\frac{\partial \ln A(a,\phi)}{\partial a} < 0$ if

$$\frac{\phi - a}{\phi + a} < \left(\frac{1-a}{1+a}\right)^{\frac{1}{\phi}}$$

hence if

$$\left(\frac{\phi - a}{\phi + a}\right)^{\phi} < \left(\frac{1-a}{1+a}\right)$$

since $\left(\frac{\phi-a}{\phi+a}\right)^{\phi}$ is increasing in ϕ, the above condition is true, thus

$$\frac{\partial \ln A(a,\phi)}{\partial a} < 0$$

and proposition 2.2 is demonstrated.

A.2 Proof of proposition 3.1

The choice of a mixed firm on respect to a public firm depends on $\widehat{\theta_M}^* \geq \widehat{\theta_G}^*$ and thus on

$$h_G \leq \frac{b_F}{1 - b_G} h_F \tag{A.24}$$

thus a mixed firm is preferred on a public one higher the appropriability parameters are and lower the efficiency of public partner is on respect to the efficiency of private partner.

The choice of a mixed firm on respect to a regulated private firm depends on $\widehat{\theta_M}^* \geq \widehat{\theta_G}^*$, hence

$$h_G \geq \frac{1 - b_F - \beta(a)}{b_G} h_F \tag{A.25}$$

thus a mixed firm is preferred on a private one higher the appropriability parameters are, higher the efficiency loss for moral hazard is and higher the efficiency of public partner is on respect to the efficiency of private partner.

Comparing equation A.24 and A.25 we can find the condition for which a mixed firm is preferred:

$$\frac{1 - b_F - \beta(a)}{b_G} \leq \frac{h_G}{h_F} \leq \frac{b_F}{1 - b_G} \tag{A.26}$$

this is true when

$$\beta(a) \geq 1 - \frac{b_F}{1 - b_G}$$

B Equivalence condition among governance structure

B.1 Public production vs private one

The decision to directly produce a public sector or to assign it to a private entrepreneur depends on government intertemporal utility function, while the decision of accepting the proposal depends on firm's utility intertemporal function.

Let us assume that the instantaneous utility function of government ($\Gamma(T,\widehat{\theta})$) depends both on a sum T that government receives and can spend for whatever it wants and on the average quality improvement it receives.

$$\Gamma\left(T,\widehat{\theta}\right)=\alpha T+(1-\alpha)\widehat{\theta} \tag{B.1}$$

$0\leq\alpha\leq 1$ is the weight of financial earnings on the utility function of government.

Thus when production is public $\Gamma\left(\Pi_G^*,\widehat{\theta_G}^*\right)=\alpha\Pi_G^*+(1-\alpha)\widehat{\theta_G}^*$, while when the production is private $\Gamma\left(J,\widehat{\theta_F}^*\right)=\alpha J+(1-\alpha)\widehat{\theta_F}^*$, where J is the concession rental by which government extracts as surplus from the firm[11]. Let us assume that firm could wait for I periods before accepting to sign the concession contract and τ is the length of the concession. Moreover let us suppose that before the concession is signed and after it is ended, government produces services directly, thus the intertemporal utility of government is:

$$\begin{aligned} U_G(J,\widehat{\theta_F}^*,I) &= \int_0^I \Gamma\left(\Pi_G^*,\widehat{\theta_G}^*\right)e^{-rt}dt \\ &+ \int_I^{i+\tau}\Gamma\left(J,\widehat{\theta_F}^*\right)e^{-rt}dt \\ &+ \int_{i+\tau}^{\infty}\Gamma\left(\Pi_G^*,\widehat{\theta_G}^*\right)e^{-rt}dt \end{aligned} \tag{B.2}$$

Thus government would like to privatise the service if

$$U_G(J,\widehat{\theta_F}^*,I)>U_G(\Pi_G^*,\widehat{\theta_G}^*,I)\;\Rightarrow\;\Gamma\left(J,\widehat{\theta_F}^*\right)>\Gamma\left(\Pi_G^*,\widehat{\theta_G}^*\right) \tag{B.3}$$

thus J must be set at this level:

$$J\geq(1-\phi)\,p\theta\widehat{\theta_G}^*-\frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^*-\widehat{\theta_G}^*\right) \tag{B.4}$$

The intertemporal utility function of private entrepreneur is:

$$U_F(\Pi_F^*-J,I)=P(J,I)\int_I^{I+\tau}(\Pi_F^*-J)\,e^{-rt}dt=\frac{P(J,I)e^{-rI}}{r}(\Pi_F^*-J)\left(1-e^{-r\tau}\right) \tag{B.5}$$

where $P(J,I)$ is the probability to win at time I an offer with $J_I\geq J$. The intuition behind $P(J,I)$ is that private firm participate to an auction offering $\widehat{\theta_F}^*$ knowing the rental J, if firm rejects the offer it knows that at time I (also for $\lim I=0$) it could win an equal or better offer with probability $P(J,I)$ since another firm may win the auction. Such probability should decrease with I and increase with J.

If firm cannot postpone its decision of either accepting or not accepting the offer, it accepts $U_F>0$, so:

$$J\leq(1-\phi)\,p\theta\widehat{\theta_F}^* \tag{B.6}$$

therefore concession contract can be sign only if

$$(1-\phi)\,p\theta\widehat{\theta_G}^*-\frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^*-\widehat{\theta_G}^*\right)\leq J\leq(1-\phi)\,p\theta\widehat{\theta_F}^*$$

which is always true if $\widehat{\theta_F}^*\geq\widehat{\theta_G}^*$ and thus $h_F>h_G$, otherwise service production must be public.

[11] It is equivalent to say that government privatises the production of services selling it to a private firm at a cost equal to the actual value of the annual sum of rents J.

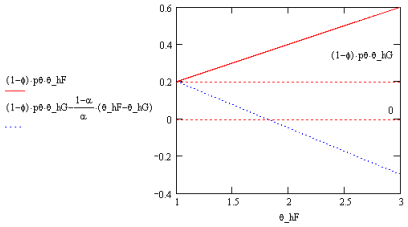

Figure 2: J boundaries

The red line of figure 2 is the firm's participation constraint, while the blue one is the condition to privatise public services production; the two lines start from the same point $\Pi_G^* = \Pi_F^*$, then they diverge.

Clearly if firm cannot postpone its decision ($I = 0$), it accepts all proposal with $J = \Pi_F^* - \varepsilon$, with $\varepsilon > 0$ however small.

If firm can postpones its decision, it has to evaluate the gain of postponing and thus it is necessary to investigate on the probability to win an equal or worse offer after I period. Such probability has to decrease with the time that firm waits before accepting I and to increase with the rental which as to be paid J. For simplicity let us assume that $P(J, I)$ is uniform distributed with J between the two boundary in figure 2 and that decreases at a constant rate λ with I, thus:

$$P(J,I) = \frac{J - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)}{\Pi_F^* - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)} e^{-\lambda I} \tag{B.7}$$

Substituting equation B.7 in equation B.5 and maximising, we may calculate the optimal value of J_F^* for firm, if a firm could choose the rental, it would pay J_F^*:

$$J_F^* = \frac{1}{2}\left(\Pi_F^* - \Pi_G^*\right) + \frac{1}{2}\frac{1-\alpha}{\alpha}\left(\theta_F^* - \theta_G^*\right) \tag{B.8}$$

thus, if the rental is greater that its optimal value $J > J_F^*$, firms will accept to postpone the concession only if it expects that the rental it will pay when it will sign the contract will be lower. In particular a firm will postpone the concession start if it expects that $U_F(\Pi_F^* - J_0, 0) \leq U_F(\Pi_F^* - J(I)^e, I)$, so:

$$\begin{aligned} \frac{P(J_0,0)}{r}\left(\Pi_F^* - J_0\right)\left(1 - e^{-r\tau}\right) &\leq \frac{P(J(I)^e,I)e^{-rI}}{r}\left(\Pi_F^* - J(I)^e\right)\left(1 - e^{-r\tau}\right) \\ I(J^e) &\leq \frac{1}{\lambda + r}\ln\left\{\frac{\left[J^e - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)\right]\left(\Pi_F^* - J^e\right)}{\left[J_0 - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)\right]\left[\Pi_F^* - J_0\right]}\right\} \end{aligned} \tag{B.9}$$

It is easy to show that for $J_F^* \leq J^e \leq J_0$, firms wait an amount of time I which is decreasing in J^e.

Let us analise the behavior of government which asks for a rental J_0, it expects that firms would wait I^e before accepting the concession, in this case it could reduce the rental J^G to anticipate the acceptance of a firm. Government would reduce its rental so that $U_G(J^G, \widehat{\theta_F}^*, 0) \geq$

$U_G(J_0, \widehat{\theta_F}^*, I^e)$, thus the optimal response in asking for a rental J^e depends on I^e and it is:

$$\begin{array}{rcl} \Gamma(J^G, \widehat{\theta_F}^*) & \geq & \Gamma(\Pi_G^*, \widehat{\theta_G}^*)(1 - e^{-rI^e}) + e^{-rI^e}\Gamma(J_0, \widehat{\theta_F}^*) \\ I(J^G) & \geq & \frac{1}{r} \ln \left[\frac{J_0 - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)}{J^G - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)} \right] \end{array} \tag{B.10}$$

Thus the equation B.9 represents the reaction function of a firm which decides the length of time for postponing the contract on the basis of expected rental J^e, the equation B.10 is the optimal response of government in offering a concession at a rental J^G to avoid the firm postpones the acceptance of I^e period, note that the utility of government decreases when reducing J^G.

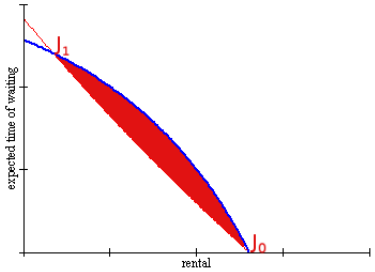

Figure 3: Postponing the concession

The filled area in figure 3 shows the area where both postponing the acceptance of concession and reducing the rental request is the optimal response for firm and government respectively, as we show in the figure 3 the reaction functions have two intersections J_1 and J_0 where J_1 is decreasing in J_0. The nash equilibrium is $J^* = J^G = J^e = J_0 = J_1$ and thus[12]:

$$J^* = \frac{2r + \lambda}{3r + \lambda}\Pi_F^* + \frac{r}{3r + \lambda}\left[\Pi_G^* - \frac{1 - \alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)\right] \tag{B.11}$$

which is a weighted mean between J boundaries, thus if it is possible to postpone the acceptance of a concession, the firm can pay a rental lower than the one on the participation constraint.

Proposition B.1 *The nash equilibrium rental is always increasing in the tacit knowledge level of government while it is decreasing in the knowledge of private firm only if the weight of rental in government utility is lower than a threshold* $\alpha < \alpha^* = \frac{r}{(2r+\lambda)(1-\phi)p_\theta + r}$*, otherwise it is increasing also in knowledge of private firm. Moreover it is increasing in the probability to find a offer J waiting I periods.*

The first part of this proposition says that an high knowledge of government reduces the power of firms in asking for a lower rental, it is not surprising since in this case public production is more efficient, the second part says that an high knowledge of firm reduces the power of government in setting the rental only if the rental is not so important for government.

Proof. Taking the two reaction function B.9 and B.10 and equating them we obtain:

$$\ln\left(\frac{\Pi_F^* - J}{\Pi_F^* - J_0}\right) = \frac{\lambda + 2r}{r} \ln\left(\frac{J_0 - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)}{J - \Pi_G^* + \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)}\right) \tag{B.12}$$

[12]The proof in the appendix.

this equation is always satisfied when $J = J_0$ since in both sides we have $\ln 1 = 0$, the existence of a second solution can be demonstrated studying the left ($LHS(J)$) and the right ($RHS(J)$) hand side of B.12, it is easy to show that both sides are decreasing in J, since $\frac{\partial}{\partial J} LHS(J) < 0$ and $\frac{\partial}{\partial J} RHS(J) < 0$, while the left hand side is concave ($\frac{\partial^2}{(\partial J)^2} LHS(J) < 0$) and the right hand side is convex ($\frac{\partial^2}{(\partial J)^2} RHS(J) > 0$). Moreover since J is between an upper and a lower bounding, we have that when $J = \Pi_G^* - \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)$, the lower bounding, RHS goes to ∞ while $LHS \geq 0$ is finite; when $J = \Pi_F^*$, the upper boundary, LHS goes to $-\infty$, while $RHS \leq 0$ but finite.

From this results, an equation with these left and right hand sides can only have no solution, two solutions (or one solution when LHS and RHS are tangent). Since a solution always exists and it is $J = J_0$, we have the nash equilibrium when J_0 is set at a level for which LHS and RHS are tangent. The two side are tangent $J^* = J_0 = J_1 = J_G = J^e = \frac{2r+\lambda}{3r+\lambda}\Pi_F^* + \frac{r}{3r+\lambda}\left[\Pi_G^* - \frac{1-\alpha}{\alpha}\left(\widehat{\theta_F}^* - \widehat{\theta_G}^*\right)\right]$, that is the equation B.11, setting $J_0 < J^*$ it is easy to show that $J_1 > J_0$, while if $J_0 < J^*$, $J_1 < J_0$. ■

B.2 Public and private production vs Institutional PPP

The case of an institutional partnership may be considered as a partial privatization case, when government sells a participation to private partner, or a joint venture between private and public when private partner adds new organizational factors. Let μ be the share of government in the PPP, this is also the share of profit that government receives. Following the suggestion of EU, institutional PPP is a way to internalise the authority in the firm, since a member of government is in the board of the firm. Thus for simplicity we assume that in PPP both partners know their efficiency parameters reciprocally. What is interesting here is that such parameters cannot simply be added, in effect the impact of tacit knowledge in quality improvements depends on how the two knowledge stocks merge together. At this stage of analysis let us set define:

$$\sigma = \frac{\Pi_M^*}{\Pi_G^*} = \frac{\widehat{\theta_M}^*}{\widehat{\theta_G}^*} \tag{B.13}$$

thus σ is a proxy for synergy among different stocks of knowledge and a proxy of organizational capacity to merge them.

Hence, government must compare $U_G(\mu\Pi_M^*, \widehat{\theta_M}^*, I)$ with $U_G(J, \widehat{\theta_F}^*, I)$ and $U_G(\Pi_G^*, \widehat{\theta_G}^*, I)$. In a one shot game ($I = 0$), it is sufficient to compare the instantaneous utility function $\Gamma(\mu\Pi_M^*, \widehat{\theta_M}^*)$, $\Gamma(J, \widehat{\theta_F}^*)$ and $\Gamma(\Pi_G^*, \widehat{\theta_G}^*)$, while the firm must accept whatever proposal on condition that $1 - \mu > 0$ or $\Pi_F^* - J > 0$. Assuming the equality for firms participation constraint and comparing instantaneous utility function it is easy to show that a PPP solution is rejected if $\sigma < 1$, i.e. only if the contribution of merging tacit knowledge is positive a PPP is a viable solution. In this case the following proposition holds:

Proposition B.2 *The institutional PPP solution is more preferred higher is the impact of public tacit knowledge.*

Proof. A PPP is preferred if $\sigma > \frac{\Gamma(Pi_F^*, \widehat{\theta_F}^*)}{\Gamma(Pi_G^*, \widehat{\theta_G}^*)}$. ■ The increase of mixed enterprise on respect to public production (σ) should be greater than the increase coming from private production $\left(\frac{\Gamma(Pi_F^*, \widehat{\theta_F}^*)}{\Gamma(Pi_G^*, \widehat{\theta_G}^*)}\right)$.

In this case $\mu = 1 - \varepsilon$ where $\varepsilon > 0$ however small. Following the same reasoning of the previous section, we may investigate the case of postponing the acceptance of PPP contract.

If we assume that the probability of finding a not better offer after I periods is:

$$Q(\mu, I) = \frac{\mu - \left(\frac{1}{\sigma} - \frac{1-\alpha}{\alpha}\left(\frac{\sigma-1}{\sigma}\right)\frac{\theta G}{\Pi G}\right)}{1 - \left(\frac{1}{\sigma} - \frac{1-\alpha}{\alpha}\left(\frac{\sigma-1}{\sigma}\right)\frac{\theta G}{\Pi G}\right)} e^{-\varphi \cdot I} \tag{B.14}$$

thus the nash equilibrium is:

$$\mu^* = Max\left(0, \frac{2r+\varphi}{3r+\varphi} + \frac{r}{3r+\varphi}\left(\frac{1}{\sigma} - \frac{1-\alpha}{\alpha}\frac{\sigma-1}{\sigma}\frac{1}{(1-\varphi)\,p\theta}\right)\right) \tag{B.15}$$

Proposition B.3 *The nash equilibrium share of partial privatisation is decreasing with the contribution of private partner to quality improvements. In effect* $\frac{\partial \mu^*}{\partial \sigma} < 0$. *Moreover it is increasing in the probability* φ.

From propositions B.1 and B.3 the following follows:

Proposition B.4 *If we assume that a private, a public and a mixed firm have the same production parameter* ϕ *and they face the same interest rate* r. *Thus* $\Pi_M^* = \Pi_F^*$ *if* $\widehat{\theta_M}^* = \widehat{\theta_F}^*$; *moreover if the rate of probability decreasing is the same* $\lambda = \varphi$, *then* $J^* = \mu^* \Pi_M^*$ *and* $\Gamma(\mu^* \Pi_M^*, \widehat{\theta_M}^*) = \Gamma(J^*, \widehat{\theta_M}^*)$. *Finally if the length of concession is the same for both a private and a mixed firm* $\tau_F = \tau_M$, *then also the utility function are the same:* $U_G(J^*, \widehat{\theta_F}^*, I) = U_G(\mu^* \Pi_M^*, \widehat{\theta_M}^*, I)$ *and* $U_F(J^* - \Pi_F^*, I) = U_F((1-\mu)\Pi_M^*, I)$.

From proposition B.4 the following results are derived starting from an indifferent situation between a private concession or a mixed enterprise ($U_G(J^*, \widehat{\theta_F}^*, I) = U_G(\mu^* \Pi_M^*, \widehat{\theta_M}^*, I)$ and $U_F(J^* - \Pi_F^*, I) = U_F((1-\mu)\Pi_M^*, I)$):

1. when the quality improvements of private firm increases on respect of the one of a PPP, both firm and government prefer a private concession;

2. when the length of private concession increases on respect to the one of mixed enterprise, both firm and government prefer a private concession[13];

3. when the rate (λ) of the decreasing of the probability to find a rental J^* increases on comparison to the rate (φ) of probability decreasing to find a share $1 - \mu^*$, firm prefers a PPP concession, while government prefers a private one, since an increasing in λ increases J^*.

The point 3 suggests that if $\partial\lambda > \partial\varphi$, firm should accept to pay a rental $J > J^*$.

[13]The firm result is not surprising, the government's depends on the hypothesis on the scrap value at the end of the concession which is the actual value of $\Gamma(\Pi_G^*, \widehat{\theta_G}^*)$.

References

[12] Antonelli C., 2005 "Models of knowledge and systems of governance", Laboratorio di Economia dellInnovazione Franco Momigliano, working paper 1, Torino.

[12] Atkinson A., Stiglitz J., 1969, "A new view to technological change", Economic Journal, Vol. 79, n. 3.

[12] Cavaliere A., Scabrosetti S., 2006, "Privatisation and efficiency: from principal and agents to political economy", Siep working papers, n. 480.

[12] Cimoli M., Dosi G., 1994, "Technological paradigms, patterns of learning and development: an introductory roadmap", IIASA working papers 94, n. 83.

[12] Florio M., 2004, *The Great Divestiture: Evaluating the Welfare Impact of the British Privatizations, 1979-1997*, MIT press.

[12] Laffont J., Tirole J., 1993, A theory of incentives in Public Procurement, MIT Press.

[12] Megginson W., Netter J, 2001, "From state to market: a survey of empirical studies of privatization", Journal of Economic Literature, vol. 39, n. 2.

[12] Oecd, 2003, Privatising state-owned enterprises. An overview of policies and practices in Oecd countries. Paris.

[12] Perotti E., 1995, "The American Economic Review", vol. 85, n. 4.

[12] Sappington D., Stiglitz J. E. (1987), "Privatization, Information and Incentives", Journal of Policy Analysis and Management, vol. 6, n. 4.

[12] Willner J., 2001, "Ownership, efficiency, and political interference", European Journal of Political Economy, vol. 17, n. 4.

[12] Shirley M., Walsh P., 2004, "Public versus private ownership: the current state of the debate", The World Bank.