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Administrative Bureaus with Standard Operating Procedures

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Abstract

We investigate the terms of exchange between the legislative branch of the government and an administrative bureau with standard operating procedures. An administrative bureau is a not-for-profit public organisation responsible for the production of a non-marketable good. Such a bureau is tax-financed and the budget appropriations can be linked directly to a verifiable measure of the agency's performance. Also, the tax-financed transfer must not be less than the monetary cost of running the public agency. When standard operating procedures are central to the workings of the bureau, the agency is unencumbered by moral hazard. Yet, such agency is likely to have superior information over its production technology relative to the legislature. In such an information environment, we focus on how the legislature could minimise its welfare losses. Our results come in striking contrast to those in the literature on bureaucracies and to the received adverse selection findings. In a setting where the agency can be either of two cost-types, the principal finds it optimal in most cases to distort the production performance of the bureau regardless of its cost-type. Also the distortions are not of the same direction.

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We investigate the terms of exchange between the legislative branch of the government and an administrative bureau with standard operating procedures (ABSOP). An administrative bureau is a not-for-profit public organisation responsible for the production of a non-marketable good. Such a bureau is tax-financed and the budget appropriations can be linked directly to a verifiable measure of the agency's performance. Also, the tax-financed transfer must not be less than the monetary cost of running the public agency. When standard operating procedures are central to the workings of the bureau, the agency is unencumbered by moral hazard. Yet, such agency is likely to have superior information over its production technology relative to the legislature. In such an information environment, we focus on how the legislature could minimise its welfare losses. Our results come in striking contrast to those in the literature on bureaucracies and to the received adverse selection findings. In a setting where the agency can be either of two cost-types, the principal finds it optimal in most cases to distort the production performance of the bureau *regardless* of its cost-type. Also the distortions are not of the same direction.

Effectively, the problem we investigate here is a principal-agent problem with hidden information, with the principal being identified with the legislature and the agent being identified with an ABSOP. Such a problem, in its standard form, has been used briefly in discussing the design of bureaucracies. This paradigm has also been used extensively in studies of procurement and regulation.

The main message of this paradigm is that the principal must leave rents with the agent who has an incentive to mis-report his type, in order to prevent him from doing so, and that these rents are decreasing with the production undertaken by the agent who has no incentive to mis-report his private information. Accordingly, the principal faces a trade-off between information rents and output distortion. This trade-off leads to underproduction on the part of the agent who has no incentive to deviate from truth-telling.

Nevertheless, in the standard version of this problem the principal is encumbered only by an information and a voluntary-participation constraint. In this paper, instead, we postulate, as we have already mentioned, that when an administrative bureau is designed its political principal(s) are also restricted by the constraint that the budget must be as low as the monetary production costs. This constraint, in conjuction with the fact that the bureau's manager may not aim at profit maximisation, implies that the legislature, when it contemplates what incentive-compatible contract to offer to the bureau, does not need to worry that the agency will reject its offer and hence that public output will not be produced. The reason is that the administrative constraint the enacting legislature faces is stricter than the agency's participation constraint.

The fact that, due to the agency's preferences, the administrative constraint makes redundant the voluntary-participation constraint implies that in analysing the optimal mechanism vis-a-vis a not-for-profit public agency which produces a non-marketable good we end up with a non-standard adverse selection problem. In more detail, the principal still faces a trade-off between information rents and output distortions, as it is the case in the standard paradigm. Yet, in our case, information rents can be reduced by distorting the production undertaken by all types of the agent. The latter implies that, in a two-types setting, we can find instances where the low-cost agent undersupplies and the high-cost agent oversupplies its output under the optimal revelation mechanism, and cases where the reversed production scheme is implemented.

1 Introduction

The understanding of the workings of the government and, in particular, the determination of government policies requires the development of a theory of public administration - the executive branch of the government. The first big steps towards a theory of public agencies took place with Tullock (1965) and Downs (1967). The first formal model of bureaucracy is due to Niskanen (1971). More recent accounts of public administration, which have deservedly established themselves in the economics and political science, are Wilson (1989) and Horn (1995), to mention few.[1]

The starting point of a theory of public administration is that the legislative branch of the government faces time and resource constraints that limit its ability to administer the enacted policies. These limitations imply that the enacting legislature may have an incentive to delegate the administration of government policies to public bureaus. Nevertheless, if the legislature has incomplete information concerning the activities of the agency, delegation will give rise to agency slippage. That is, delegation may suffer from the agency possessing private information over its endogenous choices. In addition, a public bureau may be an 'expert' in providing certain services. In other words, because they have more time or are more competent, government officials may have superior information, relative to the legislature, about exogenous parameters which are pertinent to the administration of enacted policies. In any case, the bureau's (expected) output may not be the one preferred by the legislature.

Obviously, then, examining the determination of policies requires our understanding of what public agencies do, and why they do it. Naturally, the enacting legislature finds itself at the centre of such a theory. To mitigate agency shirking and/or the adverse selection problem, the Congress must ensure that certain mechanisms to this effect are in place. The incentives faced by bureaucrats, and thereby what government agencies do, will largely depend on the particular form these mechanisms take. What kind of restrictions bureaucrats face, on the other hand, and hence the reason why government agencies do what they do, will depend on a number of factors. Such determinants, to mention few, are why agencies are set up in the first place, how they are financed, and the extend to which and by whom their activities can be controlled.

The (modelling) possibilities are far from few, and thus so is the work that comprises the received literature.[2] This paper contributes to the further development of the theory of public administration by investigating the efficiency properties of the workings of a certain class of public organisations. In particular, we investigate the terms of exchange between the legislative branch of the government and an Administrative Bureau with Standard Operating Procedures (ABSOP). Some examples of this type of public agencies are bureaus that administer (military) procurement and tax collection, transfer agencies

[1] Hereafter, we will interchange the words bureaucrat(s), (public) bureau, (public) agency, agent(s), bureau's head and agency' head.

[2] For excellent reviews of the literature on public agencies see Moe (1997) and Wintrobe (1997).

where most of expenditure is simply passing through - like agencies that administer pensions, and the army during peacetime. We restrict our attention to the analysis of such agencies because they have not been analysed by economic theory despite the fact that, on the one hand, they are clearly as important as the rest of the public organisations and, on the other hand, this type of government bureaucracy has features that differ from standard models of procurement or other studies of bureaucracy and have important and interesting efficiency consequences.

The first defining feature of an ABSOP is that it is characterised by inputs-monitoring. In organisations with this characteristic, the actions of the employees are observable and there are processes that pertain to the observable actions. That is, the political principal(s) of such an agency can determine how allocations are related to certain standard operating procedures.[3] For example, superiors can easily verify if a tax-payer or pension-claimant has provided the agency's employees with the right documents and how many invoices have been processed in one day, and "the amount of the check is determined by an elaborate but exact formula".[4] Or, in the case of the army during peacetime, "popular accounts of service in the peacetime army ... are replete with stories about rules and procedures",[5] soldiers act under the "direct gaze" of their superiors, every detail of training and equipment is under the direct supervision of military officers, and the ability of the armed forces to deter enemy aggression can be monitored by their superiors by means of military exercises. Finally, "what dominates the task of the contract officer are the rules, the more than 1,200 pages of the Federal Acquisition Regulation and Defence Acquisition Regulation in addition to the countless other pages in DoD directives".[6] In short, moral hazard problems are very likely not to be a major concern on the part of an ABSOP's principal(s).[7] Yet, ABSOPs, are not problems-free; they may still suffer from adverse selection. For instance, civil servants in the Department of Defence often have superior knowledge on weapons systems and how they enhance military capability. Similarly, civil servants responsible for processing tax invoices and retirement benefits have better information on whether more, advanced or in number, computers will enable them to administer claims in a more efficient way. In the words of Bendor et. al. (1985) such a "bureau's superior expertise is embodied in its" private information over the "relation between intermediate and final output". Alternatively, as Horn (1995), pp 87, has documented, a public bureau's production technology and hence the true cost of production of public output will often not be verifiable.

[3] For discussions on process-monitoring in public organisations, see Wilson (1989), pp. 35, 133, 159-164, 202, 221, 244, 320-323, 375 Prendergast (2000) and Dixit (2000).

[4] Wilson (1989) pp. 35.

[5] Wilson (1989) pp. 164.

[6] Wilson (1989) pp. 321. In military procurement there is also an aditional reason why 'bureaucratic drift' migh not be a concern: the manager of a military procurment program is a military officer, "which means he cares deeply about having the best possible airplane, tank or submarine" for any given appropriation (Wilson (1989) pp. 321).

[7] See, for instance, Wilson (1989) pp. 174-175.

Accordingly, even if the legislature succeeds in inducing the agency to take up recommended actions, by means of inputs-monitoring, the agency will still have superior information over the true (monetary) costs of running the department.

A natural question then is: How can such an administrative bureau be given incentives to reveal its private information? The incentives faced by an ABSOP are partly shaped by its second defining characteristic: such an agency is set up in order to produce a non-marketable good (or service). This feature of an ABSOP implies almost by definition that such bureaus are tax-financed. Another implication is that such agencies are in general involved in producing goods with widely distributed benefits and costs. Accordingly, there is less incentive for private interests to monitor the agency or to participate in agency decision-making.[8] This implies that 'fire alarms' are less likely to work, and special-interest politics are less likely to be present in the case of administrative bureaus. In addition, the supply of such goods is in general characterised by imperfect competition, and a public bureau is often the sole provider of a given public output.[9] Moreover, the nature of the good 'sold' by an administrative bureau implies that the buyer of the agency's 'expertise', i.e. the legislature, is very likely to be a monopsonist. In other words, yardstick competition and implicit incentives in the form of career concerns are very likely to have a limited scope in the extraction of the agency's private information.[10] The final implication of the feature in question is that the bilateral trade we focus on is restricted by the requirement that the tax-financed transfer from the legislature - or sponsor - to the agency must be as low as the monetary cost of production of public output. This constraint, what we call hereafter administrative constraint, follows naturally from the fact that ABSOPs produce non-marketable goods, and thus the only source of financing the cost of running such agencies is the budget appropriation.

The third defining feature of an ABSOP is the verifiability (or contractibility) of its output. That is, the legislature, can condition the budget appropriation on the agency's output. An agency's output may differ from its mandated goal. ABSOPs can in general be divided into production and procedural organisations. The attainment of a production organisation's mandated goal is verifiable. For such an organisation, the output coincides with the mandated goal. Yet, in the case of procedural agencies, the mandated goal is not verifiable. Instead, a verifiable measure of the agency's intermediate output, towards the attainment of its mandated goal, exists and this measure can be linked with the tax-financed budget the agency can appropriate. That is, a procedural organisation's (intermediate) output is its verifiable performance measure. Some examples of production agencies are tax administration and pensions administration bureaus.[11] For such agencies the mandated goal is to 'process tax invoices

[8] See, also, Horn (1995) pp 79-82.

[9] See for instance Niskanen (1971) pp 24, Wilson (1989) pp 33, Horn (1995) pp 33 and Dixit (2000).

[10] See Horn (1995) pp 33.

[11] See Wilson (1989) pp. 35, 160-162, 244.

and retirement benefits accurately and speedily, given the available resources'. Obviously an agency's performance vis-a-vis such a goal is verifiable; for instance, accuracy can be measured by the number of mistakes in processing tax invoices, and speediness can by measured with reference to a well-defined deadline like the end of the financial year, for any given appropriations by the agency. Examples of procedural organisations are bureaus that administer military procurement[12] and the army during peacetime.[13] The mandated goal of these agencies is usually as vague and non-verifiable as to 'build up and maintain a military capability which is sufficient for the defence of the nation and the defeat of enemies during a military escalation, given the available resources'. However, despite the ambiguities inherent in such a mandated goal,[14] it is quite natural to define as the (intermediate) output of such agencies simply the number of infantry divisions, tanks, air-fighters and so on. It is also quite hard to imagine that a society will not reach an agreement that the higher the intermediate output is - for a given budget allocated to the Department of Defence - the more likely it is that the mandated goal will be attained. In addition, it is also obvious that the intermediate output of such an agency is verifiable and can be linked directly to the resources allocated to the agency by the enacting legislature.[15]

The final defining characteristic of an ABSOP is that such an agency is a not-for-profit organisation: profits is not the legitimate goal of public bureaus. This feature, in conjuction with the non-market nature of an ABSOP's output, implies that a bureau's manager may not pursue the goal of profit maximisation.

In more detail, putting aside any managerial utility costs, any organisation is in general associated with some measure of profits. In addition, managers, in any sector, are in general unable to 'pay themselves' all the profits they create, in, say, the form of higher salaries. Therefore managers may have nonpecuniary goals as well, like perquisites of office, public reputation, power and patronage. One of the possible determinants of these benefits is the size of the budget available to them, or in general the size - according to some measure - of the firm. In fact, public reputation, power and patronage are often perceived to be positively related to the size of the budget.[16] Yet, this does not imply that managers are budget-maximisers.[17] The reason is that an organisation may also benefit

[12] See Wilson (1989) pp. 320-323.

[13] See Wilson (1989) pp. 163-164, 202 and Dixit (2000).

[14] Clearly, it is difficult to prove whether the existing military capability is sufficient to defeat an enemy prior to a military engagement!

[15] The distinction we make here between an agency's mandated goals and intermediate output, is essentialy very similar to the distinction made in Wilson (1989) pp. 32-34 between a bureau's 'goals' and '(critical) tasks'.

[16] See, for instance,Niskanen (1971) pp. 38.

[17] Empirical studies has shown that salaries and careers of bureaucrats are not significantly related to the size of the budget, Johnson and Libecap (1989), Young (1991). For a related criticism see also Breton and Wintrobe (1975) and Wilson (1989) Ch. 7.

from an increased discretionary budget: the difference between the budget and the minimum cost of production.[18] For instance, one could argue that the higher the discretionary budget the easier it could be for an organisation to hire new staff, and thereby reduce the existing workload, redecorate offices, and so on. Accordingly, managers may not always pursue either the goal of profit maximisation or the goal of budget maximisation; they may instead maximise a function of both the budget and profits/discretionary budget.[19] This phenomenon, however, is more acute in public agencies. Possible reasons for this are the following. On the one hand, profits are not well defined for administrative bureaus due to the non-market nature of their 'output'. Naturally this entails a difficulty on the part of a public agency's manager in appropriating pecuniary benefits. On the other hand, even if there is some verifiable measure of profits, public agencies are in general non-profit organisations and hence any realised profits are largely appropriated by their political overseers.[20] Thus public managers have an incentive to pursue non-pecuniary benefits or 'rents'.[21] Accordingly, a bureau manager's marginal disutility of monetary production costs is likely to be lower than the marginal utility of the budget-size/revenues on the part of bureaucrats,[22] and any discussions on the efficiency of bureaucracies must (at least partly) evolve around such a tenet.

Given the above characteristics of an ABSOP, in this paper we focus on how the enacting legislature could minimise the efficiency losses which may result when agencies largely control information pertinent to the exchange relation. This problem leads to very interesting results. In particular, in a setting where the legislature is faced with an agency which can be either of two cost-types, we find that in most cases it is optimal for the principal to distort the production of the bureau *regardless* of its cost-type. Also the distortions are not of the same direction. The intuition behind this result is briefly discussed at the end of the next Section, after having drawn the links of our work to the received literature.

The organisation of the paper is as follows: Next Section discusses how our model is related to other studies of bureaucracy and procurement. Section 3 presents the model. Section 4 solves for the optimal contract offered to the bureau. Our results are discussed and compared to the ones in the received literature in Section 5. Section 6 investigates how results may change if the public agency can attract resources only up to a certain level. Finally, Section 7 concludes and points to directions for

[18] See for instance Migue and Belanger (1975).

[19] The arguments here echo the ones found in Baumol (1962), Williamson (1964) pp.3 and Jensen and Meckling (1976), to mention few. For an excellent discussion of related issues see also Tirole (1988) pp. 35-51.

[20] For a related discussion see also Wilson (1989) pp 113-120, 179-181, and Dixit (2000).

[21] An example of such practice can be found in "MoD civil servants rack up 315m bill on hotels" by Marie Woolf, The Independent, Friday 28 June 2002.

[22] In fact this observation is used by Glaeser and Shleifer (1998) to demonstrate that a bureau's manager will be less tempted to cut a pound's worth of quality than the manager of a for-profit organisation.

further research.

2 Related Literature

The first defining feature of an ABSOP is that it is free of moral hazard problems. The absence of such problems is what differentiates an ABSOP from craft and coping organisations. For some discussions on 'bureaucratic drift' and models of craft and coping organisations the reader can consult Weingast (1984), Bendor et. al. (1987b), Wilson (1989), pp. 165-171, Tirole (1994), Horn (1995), pp. 79-80, Dewatripont et. al. (1999), Prendergast (2000) and Dixit (2000).

The second defining characteristic is that such an agency is set up in order to produce a non-marketable good. Such a characteristic defines, according to Horn (1995), an administrative bureau. This feature also differentiates our work from accounts of bureaus that are responsible for the allocation of non-marketable assets or for the production of marketable goods. The allocation of non-marketable assets defines, according to Horn (1995), a regulatory agency. Work on the issues that arise when such public organisations are set up includes McCubbins (1985), McCubbins et.al. (1987, 1989), Calvert et. al. (1989), Laffont and Tirole (1993, Chs 11 and 12), Prendergast (2000), Leaver (2001), Makris and Kotsogiannis (2002). The production of marketable goods, on the other hand, defines, according to Horn (1995), a state-owned enterprise. Accounts of such agencies are, among others, Laffont and Tirole (1993, Ch 17), Tirole (1994), Hart et. al. (1997), Glaeser and Shleifer (1998) and Laffont (2000, Ch 5).

An implication of ABSOPs being responsible for the production of non-marketable goods is that such agencies are in general involved in producing goods with widely distributed benefits and costs. This, however, is not the case for regulatory agencies. Private interests are more active in monitoring a regulatory agency or in participating in regulatory decision-making. For a related discussion one can visit Wilson (1989), pp. 75-79. Another implication of the feature in question is that the tax-financed transfer from the legislature to the agency must be as low as the monetary cost of production of public output. In fact, this constraint is also part of the definition of an administrative bureau in Horn (1995), pp. 81 and 90-91. Finally, we stress that yardstick competition and implicit incentives in the form of career concerns are very likely to have a limited scope in the extraction of the agency's private information. The absence of yardstick competition and implicit incentives is not, however, a problem for the political principal(s) of a regulatory agency and state-owned enterprise. For a more detailed comparison of state-owned enterprises and administrative bureaus Horn (1995) pp 82, 170-172 and 180 is an excellent source. A more detailed comparison of regulatory agencies and administrative bureaus can also be found in Horn (1995) pp 40-43 and 79-82.

ABSOPs can be thought of being the kind of public bureaus investigated in Niskanen (1971): "Bureaucrats and their sponsors do not, in fact, talk much about output - in terms of military capability ... etc. Most of the review process consists of a discussion of the relation between budgets and activity levels, such as the number of infantry divisions... The relation between activity level and output is usually left obscure and is sometimes consciously obscured ... The activities of a bureau, however, should be recognised as intermediate services which are valuable only as a function of their effectiveness" (pp. 26-27). Clearly, then, our approach can be considered as investigating the exchange relation which has been the focus of the literature that originated from Niskanen (1971).

Notwithstanding, our approach bears a major difference with the methodology in the literature a-la-Niskanen. In this paper we assign the power of authority to the legislature, with the implication that the sponsor will design the bureau in a way that serves *best* her interests given the various constraints she may encounter in doing so. In contrast, Niskanen (1971), Migue and Belanger (1975) and Bös (2001), for instance, employ a budget-game which enables the bureau to extract the whole surplus on the part of the legislature; the agency is in effect a perfectly discriminating monopolist. Clearly, such a budget-game would never be deployed by a legislature that has the political authority of choosing the terms of its interaction with a public agency. Miller and Moe (1983), on the other hand, postulate that the legislature can prohibit the agency from behaving as a perfectly discriminating monopolist. Yet, their budget-game implies that the bureau can still make take-or-leave-it offers of per-unit prices. A branch of the literature that elaborates on the work of Niskanen (1971) investigates the efficiency properties of the outcomes of various budget-games when the sponsor is also endowed with an auditing technology which can alleviate the asymmetry of information between a bureau and its sponsor. Some indicative work along these lines is Breton and Wintrobe (1975), Bendor et. al. (1985, 1987a), Banks (1989) and Banks and Weingast (1992). However, even in these papers, it is not clear whether the political overseers of an agency could do better by enforcing an alternative budget-game.[23]

Our approach, that the sponsor will design the bureau optimally given the various constraints she faces, is also somewhat related to the early theory of congressional dominance (see, for, instance, Fiorina (1981), Barke and Riker (1982), Weingast and Moran (1983), Weingast (1984), McCubbins and Scwartz (1984)). However, in that strand of research in political control, on the one hand, the focus is on regulatory agencies and, on the other hand, the bureau and its informational advantage are given short shrift. In a sense then this theory stands as the opposite polar case to that of Niskanen.

In other words, what differentiates our work from the literature a-la Niskanen and the theory of congressional dominance is that we focus on how the enacting legislature could *minimise* the efficiency losses which may result when *agencies largely control information* pertinent to the exchange relation.[24]

[23] This issue is examined in an accompanying paper of ours.

[24] The paradigm of the legislature having the political authority of choosing the terms of its interaction with a public agency has been adopted by most of the literature on bureaucracies, including, for instance, Tirole (1994), Dewatripont et. al. (1999), Dixit (2000) and Prendergast (2000). In contrast, Niskanen (1971), postulates that the agency due to its 'expertise' has complete bargaining power. Notwithstanding, the two sources of power are different. Superior information is rooted in the 'expertise' of the bureau, whilst the agenda control stems from political authority. Hence, these two

In order to design the agency optimally, the legislature will need to condition the budget to the agency's output in a way that takes into account the hidden information problem it is faced with. The Revelation Principle, then,[25] tells us that the principal can without loss of generality focus on linking budget appropriations and public output in an incentive-compatible way: that is, in a way that induces the agency to reveal its private information. We should however note that the revelation principle raises the question of commitment on the part of the sponsor. This follows from the fact that the principal has an incentive to break the contract ex post and force the bureau to operate in an efficient, from the principal's point of view, way. This is a consequence of the legislature possessing ex post the necessary information to do so. If the sponsor cannot commit at a revelation contract when sets up the bureau, then the revelation principle no longer holds. To enable the use of the revelation principle, this paper presumes the existence of an external mechanism, like a court of law, which can enforce contracts.[26] In a sense, then, this paper examines the upper bound to the payoff of the sponsor from being involved in a principal-agent relationship with a public bureau, and the implications for the efficiency of the bureaucracy.

Effectively, the problem we investigate here is a principal-agent problem with hidden information, with the principal being identified with the legislature and the agent being identified with an ABSOP.[27] Such a problem, in its standard form, has also been used briefly in Dixit (2000) in discussing the design of bureaucracies. This paradigm has also been used extensively in studies of procurement and regulation.[28]

The main message of this paradigm is that the principal must leave rents with the agent who has an incentive to mis-report his type, in order to prevent him from doing so, and that these rents are decreasing with the production undertaken by the agent who has no incentive to mis-report his private information. Accordingly, the principal faces a trade-off between information rents and output

sources need to be treated separately. See Miller and Moe (1983) and Moe (1997) for a related argument. Note here that one can also justify the use of the principal-agent paradigm by observing that if the legislature left with the agency an extra unit of the surplus involved in the exchange relationship in question it would then reduce, in effect, the surplus on the part of the electorate. This in turn implies that the prospects of the legislature retaining its decision-maker status would largely be diminished. For a similar argument see Breton and Wintrobe (1975), Weingast (1984) and Casas-Pardo and Puchades-Navarro (2001). Anyhow, nowadays researchers of bureaucracies agree, at large, that the sponsor is the side which possesses monopoly agenda control (the sponsor holds political power and hence the legal right to tell public agencies what to do) and agencies control information.

[25] For some excellent treatments of the related literature see Fudenberg and Tirole (1991) Ch. 7 and Mas-Colell et al. (1995) Ch 23.

[26] It should be emphasised here that this is also the implicit assumption in the received literature.

[27] The implicit asumption here is that the public servants that comprise the ABSOP collude perfectly and hence can be treated as a single entity. Disentangling the interactions within the agency and the implications for the design of the organisation is a very interesting task but out of the scope of the current work, and is left for future research.

[28] See for instance Baron and Myerson (1982) and Laffont and Tirole (1993).

distortion. This trade-off leads to underproduction on the part of the agent who has no incentive to deviate from truth-telling.

Nevertheless, in the standard version of this problem the principal is encumbered only by an information and a voluntary-participation constraint. In this paper, instead, we postulate, as we have already mentioned, that when an administrative bureau is designed its political principal(s) are also restricted by the constraint that the budget must be as low as the monetary production costs. This constraint, in conjuction with the fact that the bureau's manager may not aim at profit maximisation, implies that the legislature, when it contemplates what incentive-compatible contract to offer to the bureau, does not need to worry that the agency will reject its offer and hence that public output will not be produced. The reason is that the administrative constraint the enacting legislature faces is stricter than the agency's participation constraint.

The fact that, due to the agency's preferences, the administrative constraint makes redundant the voluntary-participation constraint implies that in analysing the optimal mechanism vis-a-vis a not-for-profit public agency which produces a non-marketable good we end up with a non-standard adverse selection problem. In more detail, the principal still faces a trade-off between information rents and output distortions, as it is the case in the standard paradigm. Yet, in our case, information rents can be reduced by distorting the production undertaken by all types of the agent. This problem leads to very interesting results that come in contrast to those in the literature of principal-agent problems with hidden information. In more detail, in a two-types setting, we find instances where the low-cost agent undersupplies and the high-cost agent oversupplies its output under the optimal revelation mechanism, and cases where the reversed production scheme is implemented.

3 The Model

Our model consists of a public agency and its sponsor. The agency is the sole producer of a non-marketable good valued by the sponsor. The agency can be thought of as a group of citizens who have an expertise in the production of the non-marketable good, i.e. in the attainment of the agency's mandated goal. The sponsor is assumed to be a decision-making body that has the authority of passing legislation for determining the interaction of the polity with the public bureau. We call this body the enacting coalition/legislature or the (political) principal.

Denote with q the verifiable measure of the bureaucratic performance towards the attainment of the agency's mandated goal. Assume that $q \geq 0$. The agency's (intermediate) output, q, is produced by means of a technology which transforms θ units of the economy's composite (numeraire) good into one unit of public output. For a pensions administration bureau, the productive input of the agency may take the form of offices, computers and so on. For an army during peacetime, the productive input can be thought of as the hours of training on the part of the weapons' operators, the technology necessary to support the operation of the weapon systems and so on. For the purposes of our model, the monetary cost of production of q units of public output is given by $C(q, \theta) = F + \theta q$, where $F \geq 0$ and $\theta > 0$ are scalars. The fixed cost of production F is common knowledge.[29] The marginal cost of the agency's production θ can take either of two values. In more detail $\theta \in \{\theta_1, \theta_2\} \equiv \Theta$ with respective probabilities s and $1 - s$. These probabilities are common knowledge. Let $\Delta\theta \equiv \theta_2 - \theta_1 > 0$. Assume that θ is not verifiable.

The sponsor derives a utility $B(q)$ from the bureau's output, with $B(0) \geq 0$, $B' > 0$, $B'(0) > \lambda\theta_2$, $\lim_{q\to\infty} B'(q) = 0$ and $B'' < 0$. We follow the accounting convention that the principal bears up-front the fixed cost of setting up the agency. The utility on the part of the (political) principal net of the fixed cost is then defined by

$$U_s(q, t) = B(q) - \lambda t,$$

where t is the (tax-financed) budget allocated from the sponsor to the bureau, i.e. the units of the composite good transferred to the agency, and $\lambda > 0$ is a scalar.[30]

Denote with $R_{\max} > 0$ the upper bound on the resources the bureau can attract after the fixed costs have been incurred. That is $t \in [0, R_{\max}] \equiv T$ and $R_{\max} = \bar{C} - F$, where $\bar{C}$ is the composite good endowment of the economy. This endowment can be thought of as being the total tax revenues available for public good production.

Define with $t - \theta q$ the agency's discretionary budget. This budget is a source of both pecuniary and non-pecuniary benefits for the agency. So, for instance, bureaucrats consume the discretionary budget in the form of both wages and perquisites/rents. The agency may also derive higher prestige, reputation e.t.c. from increases in the budget per se. The bureau then maximises

$$U(t, q; \theta, a, b) \equiv bt + a(t - \theta q) = (a + b)t - a\theta q, \tag{1}$$

where $a \in [0, 1]$ and $b \geq 0$.[31] The case of $b > 0$ and $a = 0$ reflects a budget-maximising bureau a-la Niskanen. At the other extreme, the case of $b = 0$ and $a > 0$ represents a 'profit-maximising'

[29] Our results are qualitatively robust to allowing for a general cost function $C(q, \theta)$ with $C_q > 0$, $C_{qq} \geq 0$, $C_{q\theta} > 0$ and $C(0, \theta) = F$, where $F \geq 0$ is a scalar. Note our assumption that the fixed cost F is common knowledge. This assumption of ours is discussed later on.

[30] Our results are robust to allowing for a general welfare function on the part of the principal $U_s(q, t)$ with the usual properties. In the present simple set-up, one can think of λ as the (average) marginal deadweight loss of taxation on the part of the citizens whose interests are pursued by the enacting coalition. See also Laffont and Tirole (1993) and Laffont (2000). Note that in Niskanen (1971) the implicit assumption is $\lambda = 1$, which is also allowed for in our paper.

[31] Note that we implicitly assume that the marginal utility (in monetary terms) from the consumption of pecuniary benefits is equal to one and higher than the marginal utility (in monetary terms) from the consumption of non-pecuniary benefits that stem from an increase in the discretionary budget, because diverting resources towards perquisites bears in general some cost for bureaucrtas. A direct implcation of the above assumption is that the marginal utility from an increase in the discretionary budget cannot be greater than one. We also implicitly assume that the bureaucrats' utility does not depend positively on the level of output. Our results are qualitatively robust to a relaxation of this assumption.

agency. Assume hereafter that $b > 0$, and note that we restrict, thereby, our attention to the case of an agency that does not aim at profit-maximisation. The reason is twofold. First, the case of $b = 0$ leads, as it will become clear later on, to a standard adverse selection problem which is well-understood. Second, as we have argued in the Introduction we believe that administrative bureaus are not-for-profit organisations, which in turn implies that their managers do not pursue the goal of maximising the bureau's discretionary budget.

To lighten notation we also set hereafter $b = 1 - a$. Assume that a (and thus b) is common knowledge.[32] Given $b = 1 - a$, the parameter a represents the bureau head's marginal disutility of monetary production costs relative to the marginal utility of the budget-size (which is normalised to one). Clearly then the case of $a = 0$ reflects a budget-maximising agency, and, at the other extreme, the case of $a = 1$ represents a profit-maximising bureau. Note also that given $b = 1 - a > 0$ we have that we focus hereafter on the case of $a \in [0, 1)$.[33]

Define with $\pi \equiv (t, q)$ a possible allocation. Let us define also $\Pi = \{\pi/\pi \in T \times \mathbf{R}_{+}\}$. Π is the policy set vis-a-vis the bureaucracy: the set of all (technologically) possible allocations. The enacting coalition chooses an element of Π. In principle, this policy choice could be conditioned, if possible, on the marginal cost of public good production, θ, as well as on the other parameters s, a and λ. Let this choice be denoted by an asterisk.[34] In other words, a policy rule is a mapping $y : \Theta \rightarrow \Pi$ and the enacted policy rule y^* is a mapping from the set of all possible mappings y.[35] The enacted policy rule y^* is chosen by the legislature according to some criterion.

The criterion for the choice of the enacted policy rule will consist of two elements. First, it will consist of the evaluation of any given policy y : the optimisation criterion. Second, it will consist of a set of certain characteristics that any given policy y must satisfy: the set of policy constraints. The principal is assumed to maximise:

$$W(y) = E_{\theta} U_s(q(\theta), t(\theta)) = E_{\theta}[B(q(\theta)) - \lambda t(\theta)],$$

This assumption can also be motivated with reference to transfer agencies. For the case of a bureau that administers, say, pension claims, it seems natural to postulate that bureaucrats do not have a direct - or if they have it is of negligible size - stake at the accuracy and speed of administering the claims.

[32] At this point it should be noted that an implicit assumption in Niskanen (1971) and the literature that originated from this work is the one we have adopted in this paper as well. Namely that a is common knowledge. In principle a could also be private information on the part of the agency. However, in this paper the focus is on asymmetric information with respect to θ. We return to this point later on.

[33] As we will see later on, the limiting solution of our model as $a \rightarrow 1$ corresponds to the solution of the standard adverse selection problem.

[34] We supress hereafter the dependence of the (enacted) policy rule on s, a and λ.

[35] Note that such a mapping could as well be such that policies are independent of the marginal cost of production of the public good.

where E_θ denotes the expectation over θ. Let us denote with Y the set of all possible policy mappings, $Y = \{y/y(\theta) \in \Pi, \forall \theta \in \Theta\}$. The fact that the sponsor may be constrained in its policy choice is captured by stating that $y \in Y^f \subseteq Y$. Therefore, the political overseers of the public agency will implement $y^* = \arg\max_{y \in Y^f} W(y)$. In what follows we look into the set Y^f in more detail.

In this paper we postulate that the principal must choose an allocation rule from the set $Y^{AC} \equiv \{y/\ y(\theta) \in \Pi \text{ and } t(\theta) \geq \theta q(\theta), \forall\ \theta \in \Theta\}$. That is, the legislature must ensure that the budget of the agency suffices for the financing of the agency's production costs. In other words, the sponsor must not leave any residual burden to the agency regarding the production of the public good. We call this an administrative constraint. Such a policy constraint is justified by our focus on public agencies that produce non-marketable goods, and thus on agencies that have no means of financing their production costs other than their budget appropriation.[36]

We also assume that the bureau cannot be coerced by the legislator(s) to participate in some institution/mechanism for the determination of some allocation. Accordingly, the principal, when decides upon the policy rule y, faces the constraint that allocations must leave the bureau at least as well off as the agency's outside option. In this model the sponsor is the only buyer of the agency's 'expertise' and hence the bureaucrats' utility from taking up their outside option is equal to zero.[37] Let $Y^{IR} \equiv \{y/y(\theta) \in \Pi$ and $U(y(\theta); \theta, a) \equiv t(\theta) - a\theta q(\theta) \geq 0, \forall \theta \in \Theta\}$. Assume that either (a) the agency knows its cost-type prior to contracting with the legislature, or (b) the agency can always resign after it learns its cost-type. It follows then that Y^{IR} is the set of allocations which ensure that an agency of type θ receives, by accepting to produce the public output, at least as much as it would earn by deciding to refuse to offer its expertise to the polity. To induce the agency to produce the public output regardless of the underlying marginal cost of production,[38] the sponsor must then choose a policy y such that $y \in Y^{IR}$. Note however that, due to $a < 1$, the administrative constraint makes the (ex-post) participation constraint redundant.[39] That is, $Y^{AC} \subset Y^{IR}$, and hence we ignore in what follows the participation constraint.[40]

[36] This, of course, assumes implicitly that public servants are protected by means of a form of limited liability: they cannot be forced by the legislature to decrease their net asset holdings to bear part of the public output's production costs.

[37] Our forthcoming results do not rest on the assumption that the reservation utility is equal to zero. All that is needed is that the reservation utility is sufficiently low.

[38] One can assume without loss of generality that ensuring the participation of an agent to any given mechanism is always optimal from the principal's point of view. This follows from the fact that the principal can replicate the outcome of any mechanism for which the agent decides to take up an outside option of hers, by designing appropriately an alternative mechanism which provides the agent with the level of utility she could derive by taking up the outside option in question.

[39] Obviously, the same would be true if we assumed instead that the agency does not know its cost-type prior to contracting and that it cannot resign after contracting with the legislature, i.e. if Y^{IR} was given by $Y^{IR} \equiv \{y/y(\theta) \in \Pi$ and $E_\theta U(y(\theta); \theta, a) \geq 0\}$. For this reason our results are robust to the introduction of such an assumption.

[40] Note that if the bureau was a profit-maximising entity, i.e. $b = 0$ and $a > 0$ (or $a = 1$ and $b = 1 - a$), then the

Thus, note, also, that the administrative constraint effectively restricts the bargaining power on the part of the principal and increases the bargaining power on the part of the bureau.

Nevertheless, $y \in Y^{AC}$ may not be the only policy constraint that the enacting coalition may face. An enacting legislature may in principle be restricted in its policy choice by some additional constraints. One such transaction cost arises if the realisation of the marginal cost of public production is private information on the part of the bureaucrats. In fact, in this paper we view bureaucrats as specialists in the production of public output and thereby we do adopt the assumption that θ is the private information of the bureau. Assuming the existence of a perfect and benevolent device which ensures the enforceability of any contract,[41] the Revelation Principle then tells us that the sponsor can choose without loss of generality a policy rule from the set of incentive-compatible policy rules $Y^{IC} \equiv \{y/\ y(\theta) \in \Pi \text{ and } U(y(\theta);\theta,a) \geq t(\theta') - a\theta q(\theta') \equiv U(y(\theta');\theta,a),\ \forall\ \theta,\ \theta' \in \Theta,\ \theta' \neq \theta\}$.

To summarise, in this paper we investigate the problem of a political principal who has the authority of designing an administrative bureau which is characterised by marginal cost of production θ. In particular, the principal seeks to maximise his expected welfare $W(y)$ with respect to a policy rule y. In doing so, the principal is restricted by the fact that the agency possesses superior information vis-a-vis its sponsor with respect to the true production parameter θ. In addition, the enacting legislature is constrained by the requirement that the bureau's budget must at least cover the monetary cost of producing the public good. That is, the set of admissible policy rules Y^f is given by $Y^f = Y^{IC} \cap Y^{AC}$.

Before leaving this Section, we consider a particular way with which the allocation rule y^* can be implemented in reality. Note that Π is a product set. This enables the enacting coalition to replace the direct revelation contract $y^* : \Theta \rightarrow \Pi$ with a contract $d : t^*(\Theta) \rightarrow Q$, where $d(t^*(\theta)) = q^*(\theta)$ for any $\theta \in \Theta$. Under this mechanism the bureau is offered a menu of budgets $\{t^*(\theta_1),\ t^*(\theta_2)\}$. Each of the budgets from this menu is associated with a given level of production, according to the mapping d. If, then, the bureau chooses a certain budget from this menu, the agency is obliged to produce the corresponding level of public output. Accordingly, bureaucrats face, in effect, the problem of either taking up their outside option or choosing an allocation from a menu of allocations $\{y^*(\theta_1),\ y^*(\theta_2)\}$. Given that $y^* \in Y^f$, the enacting coalition can be certain that a public bureau will not take up its outside option and that if the agency is characterised by a marginal cost of production θ it will indeed choose the allocation $y^*(\theta)$.

administrative constraint would be equivalent to the ex-post participation constraint.

[41] Note that we restrict our analysis to the case of deterministic policy mappings. This can be motivated by postulating that stochastic allocation rules are hard to be enforced by a court of law.

4 The Optimal Bureaucracy

In this Section we assume that the technological upper-bound $R_{\max}$ is very large, so that we can ignore the technological constraints $t(\theta) \leq R_{\max}$ for any θ. We relax this assumption in Section 6.

We start our analysis by finding the optimal allocations when information is symmetric.[42] That is, we start with finding the solution of $\max W(y)$ subject to $y \in Y^{AC}$. It follows in a straightforward manner that the principal is better off by leaving no 'excess budget' to the agency (i.e. $t^o(\theta) = \theta q^o(\theta)$ for any $\theta \in \Theta$) and asking the bureau to provide the level of output $q^o(\theta)$ that satisfies:

$$B'(q^o(\theta)) = \lambda\theta, \ \ \theta \in \Theta. \tag{2}$$

Note that $q_1^o \equiv q^o(\theta_1) > q_2^o \equiv q^o(\theta_2) > 0$. Define also $t_i^o \equiv t^o(\theta_i)$, $i = 1, 2$.

Thus under symmetric information the budget matches the minimum cost of production We will refer hereafter to such a case as the principal leaving no rents to the agent. Furthermore, output is, as it was expected, a decreasing function of the marginal cost of production and of the sponsor's marginal disutility of a higher budget, λ. In other words, output is negatively related to the social marginal cost of production $\lambda\theta$. We will refer to the production level $q^o(\theta)$ as the efficient (from the principal's point of view) level of (public good) production.

For a given marginal cost of production θ, the principal will indeed offer the contract in question to the agency and public output will be produced if the social value of public output production $B(q^o(\theta)) - \lambda(\theta q^o(\theta) + F)$ is non-negative. Note that $B(q_1^o) - \lambda\theta_1 q_1^o \geq B(q_2^o) - \lambda\theta_1 q_2^o > B(q_2^o) - \lambda\theta_2 q_2^o > 0$. The first inequality follows from the definition of q_1^o, the second inequality follows from $\Delta\theta > 0$ and the third inequality follows from the properties of $B(q)$. Thus a sufficient condition for production to always take place under complete information is that the services of the high-cost agency are socially valuable, that is

$$B(q_2^o) - \lambda(\theta_2 q_2^o + F) \geq 0. \tag{3}$$

We maintain this assumption throughout. Accordingly, under complete information the agency is set up and the social welfare is

$$s[B(q_1^o) - \lambda\theta_1 q_1^o] + (1-s)[B(q_2^o) - \lambda\theta_2 q_2^o] - F > 0. \tag{4}$$

We now move to the investigation of the optimal contract under asymmetric information. The revelation principle tells us that this contract can take the form of a pair of sub-contracts, or allocations, (q_1, t_1), (q_2, t_2) which satisfy the following incentive-compatibility constraints:

$$U_1 \geq U_2 + a\Delta\theta q_2 \tag{5}$$

$$U_2 \geq U_1 - a\Delta\theta q_1 \tag{6}$$

[42] These allocations are denoted with the superscript o.

where $U_i \equiv t_i - a\theta_i q_i$, $t_i = t(\theta_i)$ and $q_i = q(\theta_i)$, $i = 1, 2$. These constraints simply say that a bureau will find it in its interest to choose the sub-contract which is designed for an agency of its cost-type.

Using the definitions for U_i, the administrative constraints for any value of θ become:

$$U_1 \geq (1-a)\theta_1 q_1 \tag{7}$$

$$U_2 \geq (1-a)\theta_2 q_2 \tag{8}$$

The optimal mechanism, from the sponsor's point of view, is then the pair of contracts (U_i, q_i), $i = 1, 2$, with $q_i \geq 0$, which maximise

$$s[B(q_1) - \lambda(U_1 + a\theta_1 q_1)] + (1-s)[B(q_2) - \lambda(U_2 + a\theta_2 q_2)] \tag{9}$$

subject to (5)-(8). In what follows, let us denote with $(U_i^*(a), q_i^*(a))$, $i = 1, 2$, the optimal contract offered to the agency, given the utility parameter a.[43].

Note that this is not a standard adverse selection problem, since $a \in [0, 1)$. To see this, observe that in contrast to the standard adverse selection problem, the 'reservation utilities' - i.e. the right hand side of (7) and (8) - depend on the action of the agent.[44] Interestingly, this enables the sponsor to implement the unconstrained maximum under certain conditions. In fact, we have that:

$$\begin{aligned} \text{if } \frac{q_2^o}{q_1^o} &\in [\frac{a^* - a}{1-a}, \frac{a^*(1-a)}{1-aa^*}], \text{ then} \\ q_i^*(a) &= q_i^o \text{ and } U_i^*(a) = (1-a)\theta_i q_i^*(a), \text{ for any } i = 1, 2, \end{aligned} \tag{10}$$

where $a^* \equiv \theta_1/\theta_2 \in (0, 1)$. Note that the condition in the above statement is nothing else but the requirement that the first-best solution does not violate the incentive compatibility constraints.[45] Thus, if $a^* \geq \frac{q_2^o}{q_1^o}$ and $a \in [\frac{a^* - \frac{q_2^o}{q_1^o}}{1 - \frac{q_2^o}{q_1^o}}, \frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1 - \frac{q_2^o}{q_1^o})}]$ we have that the administrative bureau will be set up and it will produce the efficient level of public good at minimum cost, regardless of the level of the marginal cost of production.[46] We will refer to this environment as the Efficient Regime:[47]

Proposition 1 (The Efficient Regime) *If $a^* \geq \frac{q_2^o}{q_1^o}$ and $a \in [\frac{a^* - \frac{q_2^o}{q_1^o}}{1 - \frac{q_2^o}{q_1^o}}, \frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1 - \frac{q_2^o}{q_1^o})}]$ we have that $q_i^*(a) = q_i^o$ and $t_i^*(a) = \theta_i q_i^*(a)$, for any $i = 1, 2$.*

Turn now to the case of $\frac{q_2^o}{q_1^o} \notin [\frac{a^*-a}{1-a}, \frac{a^*(1-a)}{1-aa^*}]$. Clearly, then $(U_i^*(a), q_i^*(a))$ will differ from the

[43] We supress the dependence of the optimal contract on λ and s.

[44] Note that if $a \to 1$ then the 'reservation utilities' tend to zero and hence our problem approximates the standard adverse selection problem (we return to this later on).

[45] Note also that this condition is not satisfied if $a \to 1$.

[46] Note that $\frac{q_2^o}{q_1^o} \in [\frac{a^*-a}{1-a}, \frac{a^*(1-a)}{1-aa^*}]$ is equivalent to $a \in [\frac{a^* - \frac{q_2^o}{q_1^o}}{1 - \frac{q_2^o}{q_1^o}}, \frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1 - \frac{q_2^o}{q_1^o})}]$. Given also that $a \in [0, 1)$, for the solution in question to be relevant it must be that $a^* \geq \frac{q_2^o}{q_1^o}$.

[47] The result that a principal may be able to implement the unconstrained optimum appears also in adverse selection problems where the reservation utility is type-dependent. See, for instance, Jullien (2000).

first-best contract.[48] The principal now has three options. One, is to set up only the low-cost agency. That is, one option is to offer a contract such that $U_2(a) = q_2(a) = 0$, $q_1(a) > 0$ and $a\Delta\theta q_1(a) \geq U_1(a) \geq (1-a)\theta_1 q_1(a)$, and bear the fixed cost F only if the sub-contract $\{U_1(a), q_1(a)\}$ is chosen by the bureau's head. Clearly, this option is available only if $a \geq a^*$. Offering this contract will result in the low-cost agency operating according to the sub-contract $\{U_1(a), q_1(a)\}$ and the high-cost agency being, in effect, shut down.[49] Obviously the optimal shutdown contract will feature $q_1(a) = q_1^o$ and $U_1(a) = (1-a)\theta_1 q_1^o$. Accordingly, under this policy the low-cost agency will be set up and it will operate in an efficient manner at the expense of no public production when the marginal cost is high. We will say that the contract $\{U_2^S(a) = q_2^S(a) = 0,\ q_1^S(a) = q_1^o,\ U_1^S(a) = (1-a)\theta_1 q_1^o\}$ is a contract with shutdown of the high-cost bureau. The resulting welfare on the part of the principal is

$$s[B(q_1^o) - \lambda(\theta_1 q_1^o + F)] > 0. \tag{11}$$

The second option for the legislature is to shut down the bureau regardless of its cost-type. That is, to offer a contract $\{U_i^O(a) = q_i^O(a) = 0,\ i = 1,2\}$, bear no fixed cost and attain zero welfare We call this policy the null contract. Clearly, this option is not optimal if $a \geq a^*$. The reason is that if $a \geq a^*$ then the principal is better off by offering the contract with shutdown of the high-cost bureau.

The third option for the principal is to set up the agency, i.e. bear the fixed cost F, regardless of its cost-type. In presenting the corresponding optimum mechanism, i.e. the optimal contract with no shutdown, it will prove useful to employ the following definitions:

$$\begin{aligned} \hat{q}_i(a),\ \text{for any } i &= 1,2,\ \text{are defined by} \\ B'(\hat{q}_1(a)) &= \lambda a \theta_1 \text{ and} \\ B'(\hat{q}_2(a)) &= \lambda\theta_2 \frac{1 - saa^*}{1-s}, \end{aligned} \tag{12}$$

$$\begin{aligned} \bar{q}_i(x) &> 0,\ \text{for any } i = 1,2,\ \text{are defined by} \\ \frac{\bar{q}_2(x)}{\bar{q}_1(x)} &= -\frac{s[B'(\bar{q}_1(x)) - \lambda\theta_1]}{(1-s)[B'(\bar{q}_2(x)) - \lambda\theta_2]} = x, \text{ for some } x > 0. \end{aligned} \tag{13}$$

We distinguish between two cases:

[48] It is interesting to note that the above implies that if we had assumed that the polity is faced with a pool of 'experts' for the provision of public services then, if $a^* \geq \frac{q_2^o}{q_1^o}$, the legislature would have appointed the agency which is characterised by a such that $a \in [\frac{a^* - \frac{q_2^o}{q_1^o}}{1 - \frac{q_2^o}{q_1^o}}, \frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1 - \frac{q_2^o}{q_1^o})}]$. Accordingly, bureaucracy would be efficient in the presence of competition between 'experts', if and only if $a^* \geq \frac{q_2^o}{q_1^o}$. For related discussions on how do politicians decide which bureaus to create see Fiorina (1982), McCubbins (1985), Calvert et. al. (1989) and Banks and Weingast (1992).

[49] Note that shutting down only the low-cost agency is not incentive compatible. In fact, such a contract would require that $q_2(a) > 0$, $U_2(a) \leq -a\Delta\theta q_2(a)$, and $U_2(a) \geq (1-a)\theta_2 q_2(a)$, which is not feasible.

4.1 The Convergence Case

This case emerges when $a^* > \frac{q_2^o}{q_1^o}$ and $a \in [0, \frac{a^* - \frac{q_2^o}{q_1^o}}{1 - \frac{q_2^o}{q_1^o}})$. Note that for this range of parameters we have that $\frac{q_2^o}{q_1^o} < \frac{a^*-a}{1-a}$ and $a < a^*$.

It turns out that for the derivation of the optimal mechanism with no shutdown we can ignore the incentive-compatibility constraint for the low-cost agency (5): this constraint is satisfied ex post as a strict inequality. We can also ignore the constraints $q_i \geq 0$. Moreover, we have that the optimal mechanism with no shutdown is given by the pair of contracts $(U_1^C(a), q_1^C(a))$ and $(U_2^C(a), q_2^C(a))$ with $U_i^C(a) = (1-a)\theta_i q_i^C(a)$, $U_2^C(a) = U_1^C(a) - a\Delta\theta q_1^C(a)$, and $q_i^C(a)$, for any $i = 1, 2$, which maximise[50]

$$s[B(q_1) - \lambda\theta_1 q_1] + (1-s)[B(q_2) - \lambda\theta_2 q_2] \tag{14}$$

subject to

$$q_2 = \frac{a^* - a}{1-a} q_1. \tag{15}$$

It follows then directly that optimal production with no shutdown is given by:[51]

$$\begin{aligned} q_i^C(a) &= \bar{q}_i(x) > 0, \ i = 1, 2 \\ \text{with } x &= \frac{a^* - a}{1-a}. \end{aligned} \tag{16}$$

Consequently, in this case excess cost of production is not a concern. In addition, public services are always produced. Furthermore, and more interestingly, output distortions are present regardless of the agency's cost-type. Specifically, given that $0 < \frac{q_2^o}{q_1^o} < \frac{a^*-a}{1-a}$, condition (16) implies that $q_2^o < q_2^C(a) < q_1^C(a) < q_1^o$. That is, the high-cost agency oversupplies and the low-cost bureau undersupplies its output. We refer to this environment as the Convergence Contract/Regime because the production distortions bring closer the production levels of the two cost-types.

The intuition behind this mechanism is the following: Recall again that the unconstrained maximum is given by $U_i = (1-a)\theta_i q_i$ and $q_i = q_i^o$ for any $i = 1, 2$. Suppose that $\frac{q_2^o}{q_1^o} < \frac{a^*-a}{1-a}$. It follows that this is not a constrained maximum since it violates (6): the high-cost agency has an incentive to report that it faces a low marginal cost. To implement $q_i = q_i^o$ at a minimum cost the principal must leave with the high-cost bureau rents of $(\theta_1 - a\theta_2)q_1 - (1-a)\theta_2 q_2$ - i.e. it must be that $U_2 = \theta_2(a^* - a)q_1$ with $q_1 = q_1^o$. The high-cost bureau is then indifferent between the two contracts, i.e. $U_2 = U_1 - a\Delta\theta q_1$ with $q_1 = q_1^o$. Note also that after surrendering these information rents (8) is not binding (due to $q_i = q_i^o$ and $\frac{q_2^o}{q_1^o} < \frac{a^*-a}{1-a}$). Thus a marginal decrease in q_1 or a marginal increase in q_2 is feasible. This implies that the sponsor is faced with the following trade-off. Decreasing marginally the output of the low-cost agent results in a change in the welfare of the principal of $s[B'(q_1) - \lambda a\theta_1]$ units. At the same time, though, a marginal decrease of the low-cost agency's output reduces the utility of an

[50] See Appendix A for more details.

[51] Note that $U_2 = U_1 - a\Delta\theta q_1$ becomes - after using $U_i = (1-a)\theta_i q_i$ for any $i = 1, 2$ - $q_2 = \frac{a^*-a}{1-a} q_1$.

agency of any type (since $U_1 = (1-a)\theta_1 q_1$ and $U_2 = \theta_2(a^* - a)q_1$). This amounts to a welfare gain of $\lambda[s(1-a)\theta_1 + (1-s)\theta_2(a^*-a)]$ units. Alternatively, the principal can increase marginally the output of the high-cost bureau and face a welfare change of $(1-s)[B'(q_2) - \lambda a\theta_2]$. By doing so the principal does not affect the utility of an agency of any cost-type (since $U_1 = (1-a)\theta_1 q_1$ and $U_2 = \theta_2(a^*-a)q_1$). In effect, then the sponsor can do even better by setting $U_1 = (1-a)\theta_1 q_1$ and $U_2 = \theta_2(a^*-a)q_1$, to induce truth-telling on the part of the high-cost agency at minimum cost, and choosing q_1 and q_2 that maximise $s[B(q_1) - \lambda\theta_1 q_1] + (1-s)[B(q_2) - \lambda\theta_2((a^*-a)q_1 + aq_2)]$ subject to the high-cost agency's administrative constraint which can be re–written as $\frac{q_2}{q_1} \leq \frac{a^*-a}{1-a}$. The solution of this problem is given by (16).[52]

Recall that in the present case we have that $a < a^*$. Hence, in this case the contract with shutdown of the high-cost bureau is not feasible. It follows then directly that:

Proposition 2 *Suppose that* $a^* > \frac{q_2^o}{q_1^o}$ *and* $a \in [0, \frac{a^* - \frac{q_2^o}{q_1^o}}{1-\frac{q_2^o}{q_1^o}})$. *Then, (a) if* $s[B(\bar{q}_1(x)) - \lambda\theta_1\bar{q}_1(x)] + (1-s)[B(\bar{q}_2(x)) - \lambda\theta_2\bar{q}_2(x)] < F$ *with* $x = \frac{a^*-a}{1-a}$ *the second-best contract is the null contract* $\{t_i^*(a) = q_i^*(a) = 0,\ i = 1,2\}$, *i.e. the principal shuts down the agency regardless of its cost-type, and (b) if* $s[B(\bar{q}_1(x)) - \lambda\theta_1\bar{q}_1(x)] + (1-s)[B(\bar{q}_2(x)) - \lambda\theta_2\bar{q}_2(x)] \geq F$ *then the second-best contract is the optimal contract with no shutdown* $\{t_i^*(a) = \theta_i q_i^*(a),\ q_i^*(a) = \bar{q}_2(x),\ i = 1,2\}$, *i.e. the agency operates under the convergence regime.*

If the variable cost of efficient production is higher when the marginal cost of production is low (i.e. if $a^* > \frac{q_2^o}{q_1^o}$) and the bureau's marginal disutility from variable production costs is sufficiently low (i.e. if $a \in [0, \frac{a^* - \frac{q_2^o}{q_1^o}}{1-\frac{q_2^o}{q_1^o}})$) then we have that if the social value of the convergence regime is non-negative the agency will be set up, it will operate at minimum cost, and the production plan $\{q_1^*(a),\ q_2^*(a)\}$ will be such that $q_2^o < q_2^*(a) < q_1^*(a) < q_1^o$. If, instead, the social value of this regime is negative the legislature will shut down the agency regardless of its cost-type. That is, the principal will incur no fixed costs and public output will not be produced.

4.2 The Divergence Case

This case emerges when either $a^* < \frac{q_2^o}{q_1^o}$ and $a \in [0,1)$ or $a^* \geq \frac{q_2^o}{q_1^o}$ and $a \in (\frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1-\frac{q_2^o}{q_1^o})}, 1)$. Note that for this range of parameters we have that $\frac{q_2^o}{q_1^o} > \frac{a^*(1-a)}{1-aa^*}$, and if $a^* > \frac{q_2^o}{q_1^o}$ then $0 < \frac{a^* - \frac{q_2^o}{q_1^o}}{1-\frac{q_2^o}{q_1^o}} < \frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1-\frac{q_2^o}{q_1^o})} < 1$.

It turns out that when we examine the optimal mechanism with no shutdown we can ignore the incentive-compatibility constraint for the high-cost agency (6): this constraint is satisfied ex post as a strict inequality. We can also ignore the constraints $q_i(a) \geq 0$. In addition, we have that the optimal mechanism with no shutdown is given by the pair of contracts $(U_1^D(a), q_1^D(a))$ and $(U_2^D(a), q_2^D(a))$ with

[52] Note that the unconstrained optimum of the problem in question is given by q_1' and q_2' such that $B'(q_1') = \lambda\theta_1(\frac{1-(1-s)\frac{a}{a^*}}{s})$ and $B'(q_2') = \lambda a\theta_2$. However, $q_2' > q_1'$ and thus $\frac{q_2'}{q_1'} > \frac{a^*-a}{1-a}$, and the constraint is violated. Accordingly, the solution to the problem in question must satisfy (16).

$U_2^D(a) = (1-a)\theta_2 q_2^D(a)$, $U_1^D(a) = U_2^D(a) + a\Delta\theta q_2^D(a)$, and $q_i^D(a)$, for any $i = 1,2$, which maximise[53]

$$s[B(q_1) - \lambda((1-aa^*)\theta_2 q_2 + a\theta_1 q_1)] + (1-s)[B(q_2) - \lambda\theta_2 q_2] \tag{17}$$

subject to

$$q_2 \geq \frac{a^*(1-a)}{1-aa^*} q_1. \tag{18}$$

Note that the constraint in the above problem is nothing else but the administrative constraint for the low-cost agency, when this agency is indifferent between the contract designed for it and the contract designed for the high-cost bureau and when the high-cost agency's administrative constraint is binding. It follows that production under this scheme is given by[54]

$$q_i^D(a) = \hat{q}_i(a) > 0, \text{ for any } i = 1,2, \text{ if } \hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a) \tag{19}$$

or

$$q_i^D(a) = \bar{q}_i(x) > 0 \text{ with } x = \frac{a^*(1-a)}{1-aa^*}, \text{ for any } i = 1,2, \text{ if } \hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a). \tag{20}$$

Accordingly, in this case as well production is strictly positive and output distortions is a problem regardless of the bureau's cost-type.[55] However, the form of output distortions here differs from the one under the Convergence Regime. In particular, we have in a straightforward manner from $\frac{q_2^o}{q_1^o} > \frac{a^*(1-a)}{1-aa^*}$ and conditions (19) and (20) that $q_2^D(a) < q_2^o < q_1^o < q_1^D(a)$. That is, the high-cost agency undersupplies and the low-cost bureau oversupplies public services. The case under scrutiny here differs also from the Convergence Regime in the sense that here problems of excess production cost may arise. The reason is that now the low-cost agency's administrative constraint may be slack, i.e. the low-cost agency may enjoy information rents. Clearly, this will be the case if and only if $\hat{q}_2(a) > \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$. Equivalently, excessive costs of production arise if and only if either $a^* < \frac{\hat{q}_2(a)}{\hat{q}_1(a)}$ and $a \in [0,1)$ or $a^* \geq \frac{\hat{q}_2(a)}{\hat{q}_1(a)}$ and $a \in (\frac{a^* - \frac{\hat{q}_2(a)}{\hat{q}_1(a)}}{a^*(1-\frac{\hat{q}_2(a)}{\hat{q}_1(a)})}, 1)$.[56] Using $U_2^D(a) = (1-a)\theta_2 q_2^D(a)$, $U_1^D(a) = U_2^D(a) + a\Delta\theta q_2^D(a)$ and the definition for $U_i(a)$ we can see that the excessive production costs (when the agency is of low cost) are equal to $\theta_2[(1-aa^*)q_2^D(a) - a^*(1-a)q_1^D(a)]$.

We refer to the above mechanism (irrespective of the existence of information rents for the low-cost agency) as the Divergence Regime/Contract because the production distortions bring further away the production levels of the two cost-types. The intuition behind this regime is similar to the one behind the Convergence Regime.

[53] See Appendix B for more details.

[54] See Appendix C for the derivation.

[55] Note that under this solution we have that $U_2^*(a) - U_1^*(a) + a\Delta\theta q_1^*(a) = a\Delta\theta(q_1^*(a) - q_2^*(a)) > 0$, and thus the high-cost bureau's incentive-compatibility constraint, (6), is not violated by the contract in question.

[56] Note that $\frac{\hat{q}_2(a)}{\hat{q}_1(a)} > \frac{a^*(1-a)}{1-aa^*}$ is equivalent to $a > \frac{a^* - \frac{\hat{q}_2(a)}{\hat{q}_1(a)}}{a^*(1-\frac{\hat{q}_2(a)}{\hat{q}_1(a)})}$. Moreover, note that $\frac{\hat{q}_2(a)}{\hat{q}_1(a)} < \frac{q_2^o}{q_1^o}$ and hence $\frac{a^* - \frac{\hat{q}_2(a)}{\hat{q}_1(a)}}{a^*(1-\frac{\hat{q}_2(a)}{\hat{q}_1(a)})} > \frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1-\frac{q_2^o}{q_1^o})}$.

Note that for the range of parameters we consider in this Sub-Section a may be lower as well as higher than a^*. Thus, apart from the Divergence Contract, in the first case shutting down the agency is also a feasible contract, and in the latter case the contract with shutdown of the high-cost bureau is also a feasible mechanism. It follows then directly that:

Proposition 3 *Suppose that* $a^* < \frac{q_2^o}{q_1^o}$ *and* $a \in [0, 1)$, *or* $a^* \geq \frac{q_2^o}{q_1^o}$ *and* $a \in (\frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1-\frac{q_2^o}{q_1^o})}, 1)$. *Then, (a) if* $s[B(q_1^D(a)) - a\lambda\theta_1 q_1^D(a)] + (1-s)[B(q_2^D(a)) - \lambda\theta_2 \frac{1-saa*}{1-s} q_2^D(a)] < F$ *the second-best contract is (i) the null contract* $\{t_i^*(a) = q_i^*(a) = 0, i = 1, 2\}$, *i.e. the principal shuts down the agency regardless of its cost-type, if* $a < a^*$, *or (ii) the contract with shutdown of the high-cost agency* $\{t_2^*(a) = q_2^*(a) = 0, t_1^*(a) = \theta_1 q_1^*(a), q_1^*(a) = q_1^o\}$, *if* $a \geq a^*$. *Also, (b) if* $s[B(q_1^D(a)) - a\lambda\theta_1 q_1^D(a)] + (1-s)[B(q_2^D(a)) - \lambda\theta_2 \frac{1-saa*}{1-s} q_2^D(a)] - F \geq s[B(q_1^o) - \lambda(\theta_1 q_1^o + F)]$ *then the second-best contract is the optimal contract with no shutdown* $\{t_2^*(a) = \theta_2 q_2^*(a), t_1^*(a) = \theta_1 q_1^*(a) + \theta_2[(1 - aa^*)q_2^*(a) - a^*(1 - a)q_1^*(a)], q_i^*(a) = q_i^D(x), i = 1, 2\}$, *i.e. the agency operates under the divergence regime. Finally, (c) if* $0 \leq s[B(q_1^D(a)) - a\lambda\theta_1 q_1^D(a)] + (1 - s)[B(q_2^D(a)) - \lambda\theta_2 \frac{1-saa*}{1-s} q_2^D(a)] - F < s[B(q_1^o) - \lambda(\theta_1 q_1^o + F)]$ *the second-best contract is (i) the contract with no shutdown, if* $a < a^*$, *or (ii) the contract with shutdown of the high-cost agency, if* $a \geq a^*$.

If the variable cost of efficient production is higher when the marginal cost of production is high (i.e. if $a^* < \frac{q_2^o}{q_1^o}$) or if the variable cost of efficient production is not lower when the marginal cost of production is low (i.e. if $a^* \geq \frac{q_2^o}{q_1^o}$) and the bureau's marginal disutility from variable production costs is sufficiently high (i.e. if $a \in (\frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1-\frac{q_2^o}{q_1^o})}, 1)$) then we have that the following cases. First, if either $a < a^*$ and the social value of the divergence regime is non-negative or if $a \geq a^*$ and the social value of the divergence regime is not lower than the social value of shutting down the high-cost agency, then the agency will be set up and the production plan $\{q_1^*(a), q_2^*(a)\}$ will be such that $q_2^* < q_2^o(a) < q_1^o(a) < q_1^*$. Also, the high-cost agency will operate at minimum cost, whilst the low-cost agency may enjoy information rents. Second, if $a < a^*$ and the social value of the divergence regime is negative the legislature will shut down the agency regardless of its cost-type. Third, if $a \geq a^*$ and the social value of the divergence regime is lower than the social value of shutting down the high-cost agency, then the legislature will shut down the high-cost agency and the low-cost agency will operate in an efficient way.

5 Comparative Statics and Discussion of Results

Summarising our results, we have that if $a < a^*$ the principal may find it optimal to shut down the agency regardless of its cost-type. Also if $a \geq a^*$ the legislature may find it optimal to shut down the high-cost agency. In this case the low-cost bureau will operate in an efficient way. When the enacting coalition finds it optimal to set up the administrative bureau, regardless of its cost-type, the high-cost bureau presents the polity with no excess-cost problem. In addition, a low-cost bureaucracy does not suffer from an excess-cost problem, unless either $a^* < \frac{\hat{q}_2(a)}{\hat{q}_1(a)}$ and the bureau is characterised by $a \in [0, 1)$ or

$a^* \geq \frac{\hat{q}_2(a)}{\hat{q}_1(a)}$ and $a \in (\frac{a^* - \frac{\hat{q}_2(a)}{\hat{q}_1(a)}}{a^*(1-\frac{\hat{q}_2(a)}{\hat{q}_1(a)})}, 1)$. Concerning the efficiency properties of the production plan, we have that if the cost of production of the efficient level of public good is strictly increasing with the marginal cost of production, $a^* < \frac{q_2^o}{q_1^o}$, then the production plan follows the scheme in the Divergence Regime; that is, the low-cost bureau is characterised by overproduction and the high-cost agency undersupplies its output. In addition, if $a^* = \frac{q_2^o}{q_1^o}$, we have that (i) if $a = 0$ then there are no output distortions, and (ii) if $a \in (0, 1)$ then the Divergence Regime is implemented. If, finally, $a^* > \frac{q_2^o}{q_1^o}$, we have that (i) if a is sufficiently low, i.e. $a \in [0, \frac{a^* - \frac{q_2^o}{q_1^o}}{1-\frac{q_2^o}{q_1^o}})$, then the Convergence Regime is implemented; that is, the low-cost bureau is characterised by underproduction and the high-cost agency oversupplies its output, (ii) if a is neither too low nor too high, i.e. $a \in [\frac{a^* - \frac{q_2^o}{q_1^o}}{1-\frac{q_2^o}{q_1^o}}, \frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1-\frac{q_2^o}{q_1^o})}]$, then the Efficient Regime is implemented, and (iii) if a is sufficiently high, i.e. $a \in (\frac{a^* - \frac{q_2^o}{q_1^o}}{a^*(1-\frac{q_2^o}{q_1^o})}, 1)$, then the Divergence Regime is implemented.

To get a closer look at how the extend of the above output distortions depend on λ, skills dispersion and the likelihood of the marginal cost being low, recall that the output of the high-cost bureau is given by $\bar{q}_2(x) = x\bar{q}_1(x)$, where $x = \frac{a^*-a}{1-a}$, if $\frac{q_2^o}{q_1^o} < \frac{a^*-a}{1-a}$, and $x = \frac{a^*(1-a)}{1-aa^*}$, if $\frac{q_2^o}{q_1^o} > \frac{a^*(1-a)}{1-aa^*} > \frac{\hat{q}_2(a)}{\hat{q}_1(a)}$. Moreover, recall that in these cases the output of the low-cost bureau is given by $s[B'(\bar{q}_1(a)) - \lambda\theta_1] + (1 - s)[B'(x\bar{q}_1(a)) - \lambda\theta_2]x = 0$. Note that x is negatively related to the marginal disutility on the part of the agency from higher production costs, a.

It follows directly that output levels are decreasing in the marginal costs of production. Moreover, since $\bar{q}_2(x) < q_2^o$ if $x = \frac{a^*(1-a)}{1-aa^*}$, we have that in this case production levels are decreasing in the probability that the marginal cost is low, whilst the effect of x (and thus of a) on output levels is ambiguous. Finally, since $\bar{q}_2(x) > q_2^o$ if $x = \frac{a^*-a}{1-a}$, we have that in this case production levels are increasing in the likelihood of the marginal cost of production being low and decreasing in the marginal disutility on the part of the bureau from higher production costs.

Recall also that the output of the θ_i-cost bureau is given by $\hat{q}_i(a) > 0$, if $\frac{q_2^o}{q_1^o} > \frac{a^*(1-a)}{1-aa^*}$ and $\frac{\hat{q}_2(a)}{\hat{q}_1(a)} \geq \frac{a^*(1-a)}{1-aa^*}$. In this case we have that $\frac{q_2^o}{q_1^o} > \frac{\hat{q}_2(a)}{\hat{q}_1(a)}$. Clearly then the output of the low-cost (resp. high cost) bureau is decreasing (resp. increasing) in θ_1, and the output of the high-cost agency is decreasing in θ_2. Furthermore, the low-cost agency's output is independent of whilst the production level of the high-cost bureau is decreasing in the probability that the marginal cost is low. In addition, production levels are decreasing in the cost of public funds. Finally, the production level of the low-cost agency is decreasing and the high-cost agency's output is increasing in the marginal disutility on the part of the bureau from higher production costs.

As our discussion in Section 2 implies our model of bureaucracy is directly comparable to the literature a-la Niskanen. The first difference of our results with that literature is that here the sponsor may find it optimal to implement a shut down policy. In more detail, if $a < a^*$ the sponsor may find it optimal to shut down the bureau regardless of the realised marginal cost of public output production, and if $a \geq a^*$ the sponsor may find it optimal; to finance public production only if the agency is of the low-cost type.

Focusing on the case where a public agency is set up regardless of its cost-type, we have that our results are strikingly different to the ones in Migue and Belanger (1974). These authors find that if $a \in (0, 1)$ then bureaucrats oversupply public services and enjoy an excessive budget, regardless of the true cost of production. In addition, they show that a higher marginal cost of production implies a less acute excessive cost problem. Finally, their analysis implies that the greater a, the more acute the excessive cost problem and the smaller the oversupply problem are.

However, we show here that bureaucratic efficiency should not be taken out of the picture. Moreover, our results imply that, even if bureaus provide an inefficient level of public goods, underproduction of the bureau's output is also a possibility. Furthermore, we also show that for sufficiently low values of a there is no excess cost problem no matter what the underlying marginal cost of production is. Finally, our model implies that the excessive cost problem is non-negatively related to and that there is no clear relationship between the extend of production inefficiencies and a. It is obvious also that our present results imply that, in contrast to Breton and Wintrobe (1975), overproduction may not be a less serious problem than excess cost of production.

One of the fundamental assumptions in Niskanen (1971) is that bureaucrats maximise their budget. Our model can be used to find the implications for the design of such an agency, by considering the case of $a = 0$. The above imply that if $a^* = \frac{q_2^o}{q_1^o}$ then the bureau operates in an efficient way. If $a^* < \frac{q_2^o}{q_1^o}$ then the administrative bureau operates under the divergence regime. If on the other hand $\frac{q_2^o}{q_1^o} < a^*$ then the public agency a-la Niskanen operates under the convergence regime.

The above findings are in contrast to the results in Niskanen (1971) and Miller and Moe (1983). Niskanen (1971) finds that a bureau, regardless of its cost-type, operates at minimum cost, whilst Miller and Moe (1983) demonstrate that when marginal production costs are sufficiently low the agency enjoys an excessive budget.[57] Furthermore, Niskanen (1971) postulates that bureaucracy oversupplies regardless of the underlying true cost of production. Finally, in Miller and Moe (1983), if the marginal cost of production is sufficiently high output is at its efficient level, and if the marginal production cost is sufficiently low then there is undersupply. As our discussion in Section 2 makes it clear, the reason for this difference in results stems from the fact that in Niskanen (1971) and Miller and Moe (1983) the sponsor is restricted to not being able to implement the best, from his point of view, mechanism.

We leave this section by taking a closer look at the behaviour of the solution without shutdown when $a \to 1$, and thus by investigating an agency that, is set up and, behaves at the limit as a profit-maximising entity. Examining this case bears an interest because when Dixit (2000) discusses hidden information problems in the design of a bureaucracy the public agency is assumed to be a profit-

[57] This result of Miller and Moe (1983) appears also in Casa-Pardo and Puchades-Navarro (2001).

maximiser. As we see below such an assumption ensures that the low-cost agency will always be set up, bureaucracy will always be inefficient, and the public agency will never operate in the Convergence Regime.

Taking the limit of the solution of our model as $a \to 1$, one can find whether such a public bureau would operate in an efficient way or not. Defining $q_i^*(1) \equiv \lim_{a\to1} q_i^*(a)$ for any $i = 1, 2$ we find that our solution approximates the solution of the standard adverse selection problem. In more detail, note that as $a \to 1$ we are in the realm of the Divergence Regime. Note also that $\lim_{a\to1} \frac{a^*(1-a)}{1-aa^*} = 0$ and that if $B'(0) > \lambda\theta_2 \frac{1-sa*}{1-s}$ then $\lim_{a\to1} \hat{q}_2(a) > 0$. It follows then directly from (19) and (20) that $q_1^*(1) = q_1^o > q_2^o > q_2^*(1) \geq 0$, with $q_2^*(1) = 0$ if $B'(0) \in (\lambda\theta_2, \lambda\theta_2 \frac{1-sa*}{1-s}]$ and $q_2^*(1) > 0$ such that $B'(q_2^*(1)) = \lambda\theta_2 \frac{1-sa*}{1-s} = \lambda\theta_2 + \lambda \frac{s}{1-s}\Delta\theta$ if $B'(0) > \lambda\theta_2 \frac{1-sa*}{1-s}$. Finally, we have that the high-cost bureau operates at minimum cost and the low-cost agency enjoys information rents equal to $\Delta\theta q_2^*(1)$.

Therefore a profit-maximising low-cost bureau will provide the efficient level of public services. The high-cost agency, on the other hand, will undersupply its output. The latter agency's budget however matches its cost of production, whilst the low-cost bureau's information advantage results in excessive cost of production if $q_2^*(1) > 0$. That is, the-low cost agency may be characterised by an excessive-cost problem while the high-cost agency always suffers from an undersupply problem.[58]

Note that the above results are in contrast to the ones in Migue and Belanger (1975). In that paper, if the bureau cares only about the discretionary budget, i.e. profits, output is at its efficient level and there is an excessive cost problem regardless of the realised marginal cost of production.[59] Our present result also imply that, in contrast to Breton and Wintrobe (1975), excess cost of production may not be a more serious problem than overproduction. In particular, the above result implies that with probability s bureaucracy is characterised by excessive costs of production and with probability $1 - s$ by underproduction.

6 Limited Resources

In this Section we examine the robustness of our results to the introduction of limited resources for the finance of public output production. That is, we investigate the optimal mechanism when the legislature is also constrained from $t(\theta) \leq R_{\max}$.

[58] Clearly, if $B'(0) \in (\lambda\theta_2, \lambda\theta_2 \frac{1-sa*}{1-s}]$ then the principal finds it optimal to shut down the high-cost agency in order to save on fixed costs. If on the other hand $B'(0) > \lambda\theta_2 \frac{1-sa*}{1-s}]$ then the legislature shuts down the high-cost bureau if and only if $(1-s)[B(q_2^*(1)) - (\theta_2 + \frac{s}{1-s}\Delta\theta)q_2^*(1)] \geq (1-s)F$.

[59] Note, however, that Migue and Belanger (1975) do find that the excessive cost problem is less acute and production is lower when the marginal cost is high.

Using the definitions for U_i, the resource constraints for any value of θ become:

$$U_1 \leq R_{\max} - a\theta_1 q_1 \quad (21)$$

$$U_2 \leq R_{\max} - a\theta_2 q_2. \quad (22)$$

Define also $q^i_{\max} \equiv R_{\max}/\theta_i$, $i = 1, 2$. Observe that $q^1_{\max} > q^2_{\max}$, in particular $a^* q^1_{\max} = q^2_{\max}$. Note that, given the assumed public production technology, if public output is produced at minimum cost, i.e. if $t = \theta_i q$, then the resource constraint $t \leq R_{\max}$ implies a technological constraint $q \leq q^i_{\max}$, and vice versa. In general, however, it might be the case, as we have seen, that $t > \theta_i q$: public production takes place at excessive costs.

Assume that $q^o_i < q^i_{\max}$. That is, assume that the efficient production plan can be financed at minimum cost given the available resources for public production. It follows then directly that the Efficient Regime is not affected by the introduction of limited resources: Proposition 1 remains valid. In addition, given that $0 < q^o_2 < \bar{q}_2(x) < \bar{q}_1(x) < q^o_1 < q^1_{\max}$ when $x = \frac{a^*-a}{1-a}$, one can also show that the same is true for the Convergence Contract: Proposition 2 remains valid.[60] In fact, under both regimes, the administrative bureau, regardless of its cost-type, absorbs less than the available resources.

Turning to the case when in the absence of limited resources the Divergence Regime is relevant, we have that in deriving the optimal mechanism without shutdown we can ignore without loss of generality the incenitve-compatibility and resource constraints for the high-cost agency. Accordingly, the mechanism in question is given by the pair of contracts $(U^D_1(a), q^D_1(a))$ and $(U^D_2(a), q^D_2(a))$ with $U^D_2(a) = (1-a)\theta_2 q^D_2(a)$, $U^D_1(a) = U^D_2(a) + a\Delta\theta q^D_2(a)$, and $q^D_i(a)$, for any $i = 1, 2$, which maximise[61]

$$s[B(q_1) - \lambda((1-aa^*)\theta_2 q_2 + a\theta_1 q_1)] + (1-s)[B(q_2) - \lambda\theta_2 q_2] \quad (23)$$

subject to

$$q_2 \geq \frac{a^*(1-a)}{1-aa^*} q_1, \quad (24)$$

$$q_2 \leq \frac{a^*}{1-aa^*}(q^1_{\max} - aq_1). \quad (25)$$

Note that the latter constraint is the resource constraint for the low-cost agency when the low-cost agency is indifferent between the contract designed for it and the contract designed for the high-cost bureau and when the high-cost agency's administrative constraint is binding.

It follows then directly that if $\frac{a^*}{1-aa^*}(q^1_{\max} - a\hat{q}_1(a)) \geq \hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ then we can ignore the latter two constraints in the above problem. Production plan is then given by $q^D_i(a) = \hat{q}_i(a) > 0$ for any $i = 1, 2$, with $\hat{q}_2(a) < q^o_2 < q^2_{\max}$ and $\hat{q}_2(a) < q^o_2 < q^o_1 < \hat{q}_2(a)$. Thus the ignored constraints are satisfied. Moreover, if $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $\bar{q}_2(x) \leq \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$, with $x = \frac{a^*(1-a)}{1-aa^*}$,

[60] See Appendix D for more details.

[61] See Appendix E for more details.

then we can ignore the last constraint in the above problem. By doing so, we have in a straightforward manner that $q_i^D(a) = \bar{q}_i(x)$ for any $i = 1, 2$, with $\bar{q}_2(x) < q_2^o < q_{\max}^2$ and $\bar{q}_2(a) < q_2^o < q_1^o < \bar{q}_1(a)$. Thus, again, the ignored constraints are not violated. Accordingly, in all these cases the divergence regime with unlimited resources we have analysed in Section 4 is still valid: Proposition 3 still holds.

Note that if $a = 0$ then $\hat{q}_1(0) \to \infty$ and $\hat{q}_2(0) < q_2^o$. Thus, $\hat{q}_2(0) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(0)$ and the divergence contract with unrestricted resources implements the production plan $\{\bar{q}_1(a^*), \bar{q}_2(a^*)\}$. Note then that due to $\bar{q}_2(a^*) < q_2^o < q_{\max}^2$ and $a^* q_{\max}^1 = q_{\max}^2$ we have that $\bar{q}_2(a^*) < q_{\max}^2 = \frac{a^*}{1-aa^*}q_{\max}^1 - \frac{aa^*}{1-aa^*}a\bar{q}_2(a^*)$. That is, if the bureau is a budget-maximising entity then the divergence contract under unrestricted resources is robust to the introduction of limited resources.

Consider, now the remaining cases of $a \in (0, 1)$, and either (a) $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\bar{q}_1(x))$, or (b) $\hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\hat{q}_1(a))$. Now, the low-cost agency's resource constraint is binding. This implies that if this agency does not enjoy information rents the principal must decrease the agency's output to meet the resource requirements. If the bureau in question operates at excessive costs the legislature must decrease any rents left to this bureau to meet the resource constraint. In any case, the sponsor must alter the production plan in order to prevent the low-cost bureau from mimicking the high-cost agency. To describe the optimal mechanism without shutdown, it will prove useful to define $\check{q}_i(a)$, for any $i = 1, 2$, by[62]

$$\check{q}_2(a) = \frac{a^*}{1-aa^*}(q_{\max}^1 - a\check{q}_1(a)) \tag{26}$$

$$\frac{s[B'(\check{q}_1(a)) - a\lambda\theta_1]}{(1-s)[B'(\check{q}_2(a)) - \lambda\theta_2\frac{1-saa*}{1-s}]} = \frac{aa^*}{1-aa^*}. \tag{27}$$

We then have the following two cases. First, suppose that $a \in (0, 1)$, $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\hat{q}_1(a))$, $\check{q}_2(a) > \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$, and either $\hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ or $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\bar{q}_1(x))$ with $x = \frac{a^*(1-a)}{1-aa^*}$. In this case, the low-cost agency's administrative constraint is non-binding, $\check{q}_2(x) < \check{q}_1(x)$ and $0 < q_i^D(a) = \check{q}_i(x) < \hat{q}_i(a)$, for any $i = 1, 2$. The latter implies that $\check{q}_2(x) < q_2^o < q_{\max}^2$. Not also that $\check{q}_1(x) \in (q_{\max}^2, q_{\max}^1)$.

Under this mechanism the high-cost agency underproduces at minimum cost without exhausting resources. The low-cost agency, on the other hand, absorbs all available resources for the production of public output. It also produces at excessive cost. Note, however, that in contrast to the case of unlimited resources, the low-cost bureau may as well produce the efficient level of public output, or even underproduce, depending on the parameters. Accordingly, in this case limited resources may prevent the sponsor from diverging the output of the low-cost and high-cost agencies.

Finally, in the remaining range of parameters, both the low-cost agency's administrative and resource constraints are binding. Thus, $q_1^D(a) = q_{\max}^1 > q_1^o$ and $q_2^D(a) = \frac{a^*(1-a)}{1-aa^*}q_{\max}^1 = \frac{1-a}{1-aa^*}q_{\max}^2 < q_{\max}^2 < q_{\max}^1$. Observe that $q_2^D(a)$ may be lower as well as higher than q_2^o. In fact, $sgn\{q_2^o - q_2\} =$

[62] See Appendix F for the derivation of the optimal mechanism in question.

$sgn\{B'(\frac{1-a}{1-aa^*}q^2_{\max}) - \lambda\theta_2\}$.

Under this mechanism the agency, regardless of its cost-type, produces at minimum cost. Also the low-cost agency overproduces and exhausts all available resources. The high-cost agency, however, does not absorb all resources, and the direction of its output distortion is ambiguous. Therefore, in this case as well limited resources may prevent the legislature from diverging the output of the low-cost and high-cost public bureaus.

It is of some interest to note that under limited resources, and for any range of parameters, *only the low-cost agency* may confront the society with a problem of *exhausted resources.* This may lead the political principal to decide to implement a shut-down policy. It is also interesting to note that when limited resources prevent the sponsor from diverging the output of the low-cost and high-cost public agencies we may have an outcome where both agencies underproduce. This is clearly in striking contrast to the results in the literature a-la Niskanen. However, we may also have an outcome where an agency overproduces at minimum cost, regardless of its cost-type. Accordingly, we may have an outcome very similar to the one advocated by Niskanen (1971). Note however that this result can emerge, in our set up, only if there are *limited* resources *and* the agency is *not* a budget-maximising entity.

7 Conclusions

We have argued that an administrative bureau with standard operating procedures is involved in a bilateral trade with the legislative branch of the government for the production of a non-marketable good. We have also emphasised that this trade is hindered by an administrative constraint which requires budget appropriations to cover monetary production costs, and that such a bureau is not a profit-maximising entity. We have also adopted he view that the sponsor of the agency, i.e. the legislature, should be treated as the side with the complete control of the agenda and not vice versa. The bureau under investigation, on the other hand, should be thought of as the side with the monopoly of information over exogenous characteristics that are pertinent to the relation. According to this view then, in the presence of an external enforcing mechanism which ensures the enforceability of contracts, one can go back to the revelation principle and investigate the optimal design of the bureaucracy in question, and the implications for the agency's inefficiencies.

The revelation principle tells us that in the absence of restrictions on contracts any form of such a bureaucracy is equivalent to an organisation in which information flows in an incentive-compatible way directly from the agency to the sponsor who transmits instructions back to the bureau about the verifiable activities to be carried out. It follows that the best organisation is obtained in the form of the optimal revelation mechanism.

Our study reveals that this revelation mechanism possesses the following characteristics. First, the public agency may not always be funded. Second, the bureaucracy under scrutiny can, under certain conditions, be efficient. In this case, the output of the low-cost agency is higher than the output of the high-cost bureau.

Third, both problems of excessive cost and inefficient levels of production may undermine the efficient operation of the bureaucracy. In more detail, excessive-cost problems are present if and only if bureaucrats' marginal disutility from higher production costs is very high. Concerning production distortions, we have that if the agency's marginal disutility from higher production costs is low enough then the low-cost agency underproduces and the high-cost bureau. That is, production levels converge, relative to efficient production. If, on the other hand, the bureau's marginal disutility from higher production costs is high the kind of production inefficiencies depends on the available resources for the finance of production costs. In particular, in the presence of unlimited resources the low-cost agency overproduces and the high-cost bureau underproduces. That is, production levels diverge relative to efficient production. Limited resources, however, may prevent the legislature from diverging the output of the low-cost and high-cost agencies, relative to efficient production.

In this paper we have assumed that bureaucrats do not have an outside option. Nevertheless, our results are valid if the derived utility from this option is not too high. An interesting exercise would be to investigate the robustness of our results to the introduction of a highly valuable outside option on the part of the agency.

Moreover, we have assumed that the only source of asymmetric information is the marginal cost of production. In reality, however, the fixed cost could also be private information on the part of the bureau. In such an environment the sponsor will be faced with bidimensional asymmetric information. This would also be the case if the bureau's preference parameter a is as well private information on the part of the agency. The investigation of the optimal design of an ABSOP in the presence of multidimensional asymmetric information is a very interesting and challenging topic and is left for future research.[63]

In our model, the administrative constraint which must be satisfied under the optimal mechanism depends, when it is expresses in agency's utility terms, on the output of the bureau and is stricter than the (standard) voluntary-participation constraint. As we have seen the resulting problem gives results that differ significantly from the ones of the standard adverse selection problems where the individual-rationality constraint is not redundant.[64] This leads us to conjecture that extending the above literature to the case that the principal faces a non-redundant 'administrative constraint' is worthwhile both from a theoretical point of view and for the deeper understanding of the operation of bureaucracy. So, for instance, one could investigate the case of a continuum of types, the case of the principal also having private information, the case of repeated interactions and the case of common agency. These tasks are

[63] For the issues involved in multidimensional mechanism design see, for instance, Armstrong (1996) and Rochet and Chone (1998).

[64] For an excellent treatment of the principal-agent model see Laffont and Martimort (2002).

left for future research.

8 Appendix

8.1 Appendix A

Ignoring (5) the first order conditions for the derivation of the optimal revelation mechanism are

$$\begin{aligned} \mu_1 &= \lambda_2 + s\lambda & (28)\\ \lambda_2 &= (1-s)\lambda - \mu_2 & (29)\\ s[B'(q_1) - \lambda a\theta_1] &= -\lambda_2 a\Delta\theta + \mu_1(1-a)\theta_1 & (30)\\ (1-s)[B'(q_2) - \lambda a\theta_2] &= \mu_2(1-a)\theta_2, & (31) \end{aligned}$$

where μ_1 is the Kuhn-Tucker multiplier of the low-cost agency's administrative constraint, μ_2 is the Kuhn-Tucker multiplier of the high-cost agency's administrative constraint and λ_2 is the the Kuhn-Tucker multiplier of the low-cost agency's incentive-compatibility constraint. Moreover, we have the following complementary-slackness conditions

$$\begin{aligned} \mu_1 &\geq 0, U_1 - (1-a)\theta_1 q_1 \geq 0, \mu_1[U_1 - (1-a)\theta_1 q_1] = 0, & (32)\\ \mu_2 &\geq 0, U_2 - (1-a)\theta_2 q_2 \geq 0, \mu_2[U_2 - (1-a)\theta_2 q_2] = 0, & (33)\\ \lambda_2 &\geq 0, U_2 - U_1 + a\Delta\theta q_1 \geq 0, \lambda_2[U_2 - U_1 + a\Delta\theta q_1] = 0. & (34) \end{aligned}$$

First, note that $\mu_1 > 0$ and thus $U_1 = (1-a)\theta_1 q_1$. Second note that $\lambda_2 > 0$. If $\lambda_2 = 0$ then the above conditions imply that $\mu_2 > 0$, $U_2 = (1-a)\theta_2 q_2$ and $q_i = q_i^o$ for any $i = 1, 2$, which violates $U_2 - U_1 + a\Delta\theta q_1 \geq 0$ given that $\frac{q_2^o}{q_1^o} \notin [\frac{a^*-a}{1-a}, \frac{a^*(1-a)}{1-aa^*}]$. Therefore, $\lambda_2 > 0$ and $U_2 = U_1 - a\Delta\theta q_1$.

Now suppose that $\mu_2 = 0$. Then the necessary conditions imply that:

$$\begin{aligned} \mu_1 &= \lambda & (35)\\ \lambda_2 &= (1-s)\lambda & (36)\\ B'(q_1) &= \lambda\theta_1(\frac{1-(1-s)\frac{a}{a^*}}{s}) & (37)\\ B'(q_2) &= \lambda a\theta_2. & (38) \end{aligned}$$

But, due to $a^* > a$, we have $a\theta_2 < \theta_1(\frac{1-(1-s)\frac{a}{a^*}}{s})$ and thus $q_2 > q_1$ which violates $U_2 \geq (1-a)\theta_2 q_2$, given that $U_1 = (1-a)\theta_1 q_1$ and $U_2 = U_1 - a\Delta\theta q_1$. Thus $\mu_2 > 0$ and $U_2 = (1-a)\theta_2 q_2$.

8.2 Appendix B

Ignoring (6) the first order conditions for the derivation of the optimal revelation mechanism are

$$\mu_2 = \lambda_1 + (1-s)\lambda \tag{39}$$

$$\lambda_1 = s\lambda - \mu_1 \tag{40}$$

$$s[B'(q_1) - \lambda a\theta_1] = \mu_1(1-a)\theta_1 \tag{41}$$

$$(1-s)[B'(q_2) - \lambda a\theta_2] = \lambda_1 a\Delta\theta + \mu_2(1-a)\theta_2, \tag{42}$$

where μ_1 is the Kuhn-Tucker multiplier of the low-cost agency's administrative constraint, μ_2 is the Kuhn-Tucker multiplier of the high-cost agency's administrative constraint and λ_1 is the the Kuhn-Tucker multiplier of the high-cost agency's incentive-compatibility constraint. Moreover, we have the following complementary-slackness conditions

$$\mu_1 \geq 0, U_1 - (1-a)\theta_1 q_1 \geq 0, \mu_1[U_1 - (1-a)\theta_1 q_1] = 0, \tag{43}$$

$$\mu_2 \geq 0, U_2 - (1-a)\theta_2 q_2 \geq 0, \mu_2[U_2 - (1-a)\theta_2 q_2] = 0, \tag{44}$$

$$\lambda_1 \geq 0, U_1 - U_2 - a\Delta\theta q_2 \geq 0, \lambda_2[U_1 - U_2 - a\Delta\theta q_2] = 0. \tag{45}$$

First, note that $\mu_2 > 0$ and thus $U_2 = (1-a)\theta_2 q_2$. Second note that $\lambda_1 > 0$. If $\lambda_1 = 0$ then the above conditions imply that $\mu_1 > 0$, $U_1 = (1-a)\theta_1 q_1$ and $q_i = q_i^o$ for any $i = 1, 2$, which violates $U_1 - U_2 - a\Delta\theta q_2 \geq 0$ given that $\frac{q_2^o}{q_1^o} \notin [\frac{a^*-a}{1-a}, \frac{a^*(1-a)}{1-aa^*}]$. Therefore, $\lambda_1 > 0$ and $U_1 = U_2 + a\Delta\theta q_2$. This condition and $U_2 = (1-a)\theta_2 q_2$ imply that $U_1 \geq (1-a)\theta_1 q_1$ can be re-written as $q_2 \geq \frac{a^*(1-a)}{1-aa^*} q_1$.

8.3 Appendix C

Consider the problem

$$\max_{q_1,q_2} s[B(q_1) - \lambda((1-aa^*)\theta_2 q_2 + a\theta_1 q_1)] + (1-s)[B(q_2) - \lambda\theta_2 q_2] \tag{46}$$

subject to

$$q_2 \geq \frac{a^*(1-a)}{1-aa^*} q_1. \tag{47}$$

If $\hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ we can ignore the (low-cost agency's administrative) constraint. The unconstraint maximum is $q_i^*(a) = \hat{q}_i(a) > 0$, with the inequality following from $\hat{q}_1(a) > q_1^o(a) > 0$ and $\hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$. Thus, the constraint is not violated at this solution.

Suppose now that $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$. It follows then that the constraint is binding. To see this note first that the first order conditions with respect to q_1 and q_2 are

$$s[B'(q_1) - \lambda a\theta_1] = \mu_1 \frac{a^*(1-a)}{1-aa^*} \tag{48}$$

$$(1-s)[B'(q_2) - \lambda\theta_2 \frac{1-saa*}{1-s}] + \mu_1 = 0, \tag{49}$$

where μ_1 is the Kuhn-Tucker multiplier of the above constraint. If $\mu_1 = 0$ the above conditions imply that $q_i = \hat{q}_i(a)$ for any $i = 1, 2$. Given $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ the constraint is violated. Hence, $\mu_1 > 0$. Eliminating μ_1 from the above conditions we then have directly that $q_i^*(a) = \bar{q}_i(x) > 0$ with $x = \frac{a^*(1-a)}{1-aa^*}$.

(Note that, due to $\hat{q}_1(a) > 0$, if $\hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ then $B'(0) > \lambda\theta_2\frac{1-saa*}{1-s}$. Note also that $B'(0) \leq \lambda\theta_2\frac{1-saa*}{1-s}$ implies $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$. In general, however, we may also have that $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $B'(0) > \lambda\theta_2\frac{1-saa*}{1-s}$).

8.4 Appendix D

Consider the range of parameters for which the convergence contract is relevant and hence $a < a^*$. Recall that the convergence contract with unconstrained resources is such that $U_2 = U_1 - a\Delta\theta q_1$ and $U_i = (1-a)\theta_i q_i$ for any $i = 1, 2$. Combining these conditions we have that $q_2 = \frac{a^*-a}{1-a}q_1$. Moreover we have that the production plan under this contract is $\{\bar{q}_1(x), \bar{q}_2(x)\}$ with $x = \frac{a^*-a}{1-a}$. Recall also that $0 < q_2^o < \bar{q}_2(x) < \bar{q}_1(x) < q_1^o < q_{\max}^1$.

Given that the low-cost agency operates at minimum cost we have directly that the corresponding resource constraint is not violated. Note now that the high-cost agency's resource constraint when $U_2 = U_1 - a\Delta\theta q_1$ and $U_1 = (1-a)\theta_1 q_1$ can be re-written as $q_1 \leq \frac{1}{a^*-a}(q_{\max}^2 - aq_2)$. Thus, if the high-cost agency's resource constraint is violated at the convergence contract we derived in Section 4 it must be that $\bar{q}_1(x) > \frac{1}{a^*-a}(q_{\max}^2 - a\bar{q}_2(x))$. This implies that $a > 0$; for, if $a = 0$ then due to $\bar{q}_1(a^*) < q_1^o < q_{\max}^1$ and $a^* q_{\max}^1 = q_{\max}^2$ we have that $\bar{q}_1(a^*) < q_{\max}^1 = \frac{a^*}{a^*-a}q_{\max}^1 - \frac{1}{a^*-a}a\bar{q}_2(x) = \frac{1}{a^*-a}q_{\max}^2 - \frac{1}{a^*-a}a\bar{q}_2(x)$ which is a contradiction.

Suppose then that $a \in (0, a^*)$ and $\bar{q}_1(x) \geq \frac{1}{a^*-a}(q_{\max}^2 - a\bar{q}_2(x))$. Given that $\bar{q}_2(x) < \bar{q}_1(x)$ we have that it must also be that $\bar{q}_1(x) > \frac{1}{a^*-a}(q_{\max}^2 - a\bar{q}_1(x))$ and thereby $\bar{q}_1(x) > q_{\max}^2/a^*$. The latter implies that $\bar{q}_1(x) > q_{\max}^1 > q_1^o$ which is a contradiction. Accordingly, the introduction of limited resources does not alter the optimal mechanism when $a \in (0, 1)$ and $\frac{q_2^o}{q_1^o} < \frac{a^*-a}{1-a}$: the agency, regardless of its cost-type, does not exhaust or absorb more than the available resources.

8.5 Appendix E

Ignoring (6) and (22) the first order conditions for the derivation of the optimal revelation mechanism are

$$\mu_2 = \lambda_1 + (1-s)\lambda \quad (50)$$

$$\lambda_1 = s\lambda - \mu_1 + \kappa_1 \quad (51)$$

$$s[B'(q_1) - \lambda a\theta_1] = \mu_1(1-a)\theta_1 + \kappa_1 a\theta_1 \quad (52)$$

$$(1-s)[B'(q_2) - \lambda a\theta_2] = \lambda_1 a\Delta\theta + \mu_2(1-a)\theta_2, \quad (53)$$

where μ_1 and κ_1 are the Kuhn-Tucker multipliers of the low-cost agency's administrative and resource constraints, respectively, μ_2 is the Kuhn-Tucker multiplier of the high-cost agency's administrative constraint and λ_1 is the the Kuhn-Tucker multiplier of the high-cost agency's incentive-compatibility constraint. Moreover, we have the following complementary-slackness conditions

$$\mu_1 \geq 0, U_1 - (1-a)\theta_1 q_1 \geq 0, \mu_1[U_1 - (1-a)\theta_1 q_1] = 0, \tag{54}$$

$$\mu_2 \geq 0, U_2 - (1-a)\theta_2 q_2 \geq 0, \mu_2[U_2 - (1-a)\theta_2 q_2] = 0, \tag{55}$$

$$\lambda_1 \geq 0, U_1 - U_2 - a\Delta\theta q_2 \geq 0, \lambda_2[U_1 - U_2 - a\Delta\theta q_2] = 0, \tag{56}$$

$$\kappa_1 \geq 0, R_{\max} - a\theta_1 q_1 - U_1 \geq 0, \kappa_1[R_{\max} - a\theta_1 q_1 - U_1] = 0. \tag{57}$$

First, note that $\mu_2 > 0$ and thus $U_2 = (1-a)\theta_2 q_2$. Second note that $\lambda_1 > 0$. If $\lambda_1 = 0$ then the above conditions imply that $\mu_1 > 0$, $U_1 = (1-a)\theta_1 q_1$ and, given $q_i^o < q_{\max}^i$, that $q_i = q_i^o$ for any $i = 1, 2$, which violates $U_1 - U_2 - a\Delta\theta q_2 \geq 0$ given that $\frac{q_2^o}{q_1^o} \notin [\frac{a^*-a}{1-a}, \frac{a^*(1-a)}{1-aa^*}]$. Therefore, $\lambda_1 > 0$ and $U_1 = U_2 + a\Delta\theta q_2$. This condition and $U_2 = (1-a)\theta_2 q_2$ imply that $U_1 \geq (1-a)\theta_1 q_1$ and $U_1 \leq R_{\max} - a\theta_1 q_1$ can be re-written as $q_2 \geq \frac{a^*(1-a)}{1-aa^*} q_1$ and $q_2 \leq \frac{a^*}{1-aa^*}(q_{\max}^1 - aq_1)$, respectively.

8.6 Appendix F

Consider the problem

$$\max_{q_1, q_2} s[B(q_1) - \lambda((1-aa^*)\theta_2 q_2 + a\theta_1 q_1)] + (1-s)[B(q_2) - \lambda\theta_2 q_2] \tag{58}$$

subject to

$$q_2 \geq \frac{a^*(1-a)}{1-aa^*} q_1, \tag{59}$$

$$q_2 \leq \frac{a^*}{1-aa^*}(q_{\max}^1 - aq_1). \tag{60}$$

It will prove useful in what follows to define $\check{q}_i(a)$, for any $i = 1, 2$, by

$$\check{q}_2(a) = \frac{a^*}{1-aa^*}(q_{\max}^1 - a\check{q}_1(a)) \tag{61}$$

$$\frac{s[B'(\check{q}_1(a)) - a\lambda\theta_1]}{(1-s)[B'(\check{q}_2(a)) - \lambda\theta_2 \frac{1-saa^*}{1-s}]} = \frac{aa^*}{1-aa^*}. \tag{62}$$

Note that if $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\hat{q}_1(a))$ then $\check{q}_i(a) < \hat{q}_i(a)$ for any $i = 1, 2$, and vice versa. Recall now that $\hat{q}_2(a) < q_2^o < q_{\max}^2$. Accordingly, if $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\hat{q}_1(a))$ we also have that $\check{q}_2(a) < q_{\max}^2$. Note also that $\check{q}_2(a) > \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$ imply that $\check{q}_1(a) < q_{\max}^1$, and vice versa. We now turn to the characterisation of the above problem's solution.

(I) Consider, first, the case of $a \in (0, 1)$, $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\hat{q}_1(a))$ (and hence $\check{q}_2(a) < q_{\max}^2$), $\check{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$, and either $\hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ or $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q_{\max}^1 - a\bar{q}_1(x))$ with $x = \frac{a^*(1-a)}{1-aa^*}$. It turns out that we can ignore the first constraint. By doing so we clearly have that $0 < q_i = \check{q}_i(x) < \hat{q}_i(a)$, for any $i = 1, 2$. Observe that $\check{q}_2(x) < \hat{q}_2(a) < q_2^o < q_{\max}^2$. Note also that $\check{q}_2(a) < q^2_{\max}$ and, by definition, $\check{q}_2(a) = \frac{a^*}{1-aa^*}(q^1_{\max} - a\check{q}_1(a))$ imply that $\check{q}_2(x) < \check{q}_1(x)$. Thus, the ignored constraints are satisfied. Note finally that $\check{q}_1(x) \in (q^2_{\max}, q^1_{\max}]$ and that $sgn\{\check{q}_1(x) - q^o_1\}$ is ambiguous.

(II) Consider now the case of $a \in (0,1)$, $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\hat{q}_1(a))$, $\check{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$, and either $\hat{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ or $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$ with $x = \frac{a^*(1-a)}{1-aa^*}$. Note that here we have $q^1_{\max} < \check{q}_1(a) < \hat{q}_1(a)$ and $\check{q}_2(a) < \hat{q}_2(a) < q^o_2 < q^2_{\max}$. Accordingly, if $\hat{q}_2(a) > \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ we have that $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$ with $x = \frac{a^*(1-a)}{1-aa^*}$. In other words, if $a \in (0,1)$, $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\hat{q}_1(a))$, $\check{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$ and $\hat{q}_2(a) \neq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ then we have $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$ with $x = \frac{a^*(1-a)}{1-aa^*}$.

The first order conditions (FOCs) with respect to q_1 and q_2 are

$$s[B'(q_1) - \lambda a\theta_1] = \mu_1\frac{a^*(1-a)}{1-aa^*} + \kappa_1\frac{aa^*}{1-aa^*} \quad (63)$$

$$(1-s)[B'(q_2) - \lambda\theta_2\frac{1-saa*}{1-s}] + \mu_1 = \kappa_1. \quad (64)$$

Note that $\mu_1 > 0$. If $\mu_1 = 0$ and $\kappa_1 = 0$ then due to $\hat{q}_2(a) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\hat{q}_1(a))$ we have that the third constraint is violated. If $\mu_1 = 0$ and $\kappa_1 > 0$ then due to $\check{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$ we have that the first constraint is violated. Thus $\mu_1 > 0$ and $q_2 = \frac{a^*(1-a)}{1-aa^*}q_1$. Note then that $\kappa_1 > 0$. Suppose the contrary, i.e. $\kappa_1 = 0$. Then the above FOCs imply that $q_i = \bar{q}_1(x)$ with $x = \frac{a^*(1-a)}{1-aa^*}$, and $q_1 < \hat{q}_1(a)$ and $q_2 > \hat{q}_2(a)$. If $\hat{q}_2(a) \neq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ the third constraint is violated due to $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$ with $x = \frac{a^*(1-a)}{1-aa^*}$. If $\hat{q}_2(a) = \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ then $q_2 > \frac{a^*(1-a)}{1-aa^*}q_1$ which is a contradiction. Thus $\kappa_1 > 0$ and $q_2 = \frac{a^*}{1-aa^*}(q^1_{\max} - aq_1)$. Accordingly, $q_1 = q^1_{\max} > q^o_1$ and $q_2 = \frac{a^*(1-a)}{1-aa^*}q^1_{\max} = \frac{1-a}{1-aa^*}q^2_{\max} < q^2_{\max}$. Finally, observe that q_2 may be lower as well as higher than q^o_2. In fact, $sgn\{q^o_2 - q_2\} = sgn\{B'(\frac{1-a}{1-aa^*}q^2_{\max}) - \lambda\theta_2\}$.

(III) Consider, finally, the case of $a \in (0,1)$, $\hat{q}_2(a) \leq \frac{a^*}{1-aa^*}(q^1_{\max} - a\hat{q}_1(a))$, $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ and $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$ with $x = \frac{a^*(1-a)}{1-aa^*}$. Note that here we have that $\check{q}_1(a) \geq \hat{q}_1(a)$ and $\check{q}_2(a) \geq \hat{q}_2(a)$. Also it must be that $\hat{q}_1(a) > q^1_{\max}$; otherwise $\bar{q}_2(x) \leq \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$. These relationships imply that $\check{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$. To see this suppose the contrary. Then, $\check{q}_2(a) \geq \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$ $\geq \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$. But by definition $\check{q}_2(a) = \frac{a^*}{1-aa^*}(q^1_{\max} - a\check{q}_1(a))$ and hence $\check{q}_2(a) \leq \frac{a^*}{1-aa^*}(q^1_{\max} - a$ $\hat{q}_1(a)) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$. Obviously, we arrived at a contradiction. Note then that due to $\hat{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\hat{q}_1(a)$ we have that $\mu_1 = \kappa_1 = 0$ cannot be the case. Also due to $\bar{q}_2(x) > \frac{a^*}{1-aa^*}(q^1_{\max} - a\bar{q}_1(x))$ we have that $\mu_1 > 0$ and $\kappa_1 = 0$ cannot be the case. Finally due to $\check{q}_2(a) < \frac{a^*(1-a)}{1-aa^*}\check{q}_1(a)$ we have that $\mu_1 = 0$ and $\kappa_1 > 0$ cannot be the case. Accordingly, $\mu_1 > 0$, $\kappa_1 > 0$ and thereby, as above, $q_1 = q^1_{\max} > q^o_1$ and $q_2 = \frac{a^*(1-a)}{1-aa^*}q^1_{\max} = \frac{1-a}{1-aa^*}q^2_{\max} < q^2_{\max}$. Once again observe that $sgn\{q^o_2 - q_2\} = sgn\{B'(\frac{1-a}{1-aa^*}q^2_{\max}) - \lambda\theta_2\}$.

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