Contracts in Bureaucracies

May 2008

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JEL Classification: D73, D82.

Keywords: Bureaucracy, professionalism, fixed budget, contract, adverse selection.

1. Introduction

> "*In the days leading up to September 30, the federal government is Cinderella, courted by legions of individuals and organizations eager to get grants and contracts from the unexpended funds still at the disposal of each agency. At midnight on September 30, the government's coach turns into a pumpkin. That is the moment – the end of the fiscal year—at which every agency, with few exceptions, must return all unexpended funds to the Treasury Department.*" In *Bureaucracy*, by James Wilson. Basic Books, 1989, p.116)

It is a characteristic of many government bureaucracies to operate under a mostly fixed budget that has to be returned if unspent. At the beginning of the fiscal year, a typical agency receives a budget that allows it to operate during the next twelve months. If the budget is not spent by the end of the fiscal year, it has to be returned to the funding organization. For instance, many state universities and government agencies operate this way. They receive a fixed budget from the legislature and, if at the end of the fiscal year some of the budget goes unspent, it has to be returned to the legislature. While unanticipated expenses may be accommodated in exceptional cases, such options are usually severely limited and quite an uncertain prospect for the agency.

In this paper, we consider a bureaucratic agency that operates under a fixed budget and must return any unspent portion of this budget to the funding authority at the end of the fiscal year. Two questions arise from such an arrangement. First, why does the funding authority operate in this manner, and second, what are the incentive effects on the bureaucratic agency? Indeed, as noted by Wilson (1989), such "agencies do not have a material incentive to economize: Why scrimp and save if you cannot keep the result of your frugality?" In this paper we focus on the second question, the incentive effects, but we begin by addressing the first question.

There is a large literature in political science that argues why funding authorities may have little control over a bureaucratic agency other than being able to fix its budget.[1] Brehm and Gates (1997) note that civil servants enjoy considerable

[1] Niskanen's notion of a budget-maximizing bureaucrat, who can choose a budget, has been widely challenged in the political science literature. Aberbach et al (1981) state that agency chiefs may argue for increments in their budgets but have little control over their budgets, and Moe (1997) cites authors who question the budget-maximizing assumption.

protection from political influence, and they cite several commentators who have advocated for such protection. Besides Max Weber's (1947) well-known fear of "dilettantism" by politicians, Woodrow Wilson (1887) also argued that a bureaucracy should remain "outside the sphere of politics", to shield bureaucrats from the narrow interests of politicians.

Even if one questions whether bureaucrats should be shielded from the influence of politicians, as a practical matter, political bodies have little knowledge in delivering public service. While Congress may want to provide an education-friendly budget by providing an increase in the allocation to education, they have to leave the details of implementation to the Department of Education run primarily by career bureaucrats. Congress may well state general goals but, as Wilson (1989) explains, bureaucracies are best defined by "tasks". Promoting the "long-range security interests of the United States" may be the stated goal of the State Department, but it is bureaucrats who must develop guidelines and implement actions to achieve such a goal. The Congress has limited ability to condition the budget on specific performance measures.

In the economics literature, Tirole (1994) also recognizes the difficulty of measuring the performance of agencies characterized by such general goals.[2] Tirole also highlights the lack of commitment abilities of political authorities. Not only the tastes of political authorities are fairly diverse but they change over time "in a non-contractible manner." This lack of time consistency prevents political authorities from committing to an incentive scheme.

Whether by design (to prevent undue political influence) or by necessity (due to lack of measurement capacity or commitment ability), the budget can be seen, to a large extent, as depending very little on the agencies' actual performance.[3]

This view of bureaucracy begs our second question: how to provide incentives to bureaucrats? The literature has identified two models of organizational design for bureaucracies (see e.g., Rose-Ackerman (1986)). At one extreme, the bureaucracies

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[2] To quote Tirole: "…..even an econometrician may have a hard time measuring the regulator's contribution to the net consumer surplus. And who will put reliable numbers on the US Department of States performance in 'promoting the long range security and well being of the United States, and on the US Department of Labor's success in 'fostering, promoting, and developing the welfare and the wage earners of the US'?"

[3] Moreover, as noted by Johnson and Libecap (1989), at the individual level, a bureaucrat is difficult to fire and a bureaucrat's salary is not tied to the agency's budget.

rely on the bureaucrat's professionalism to resolve any incentive problems. Bureaucrats are professionals. Professionals are trained in "professions which emphasize not only technical competence but also conscientious devotion to duty." (Rose-Ackerman (1986)) They receive most of their incentives from outside the bureaucracy, mainly from organized groups of fellow practitioners and the self-satisfaction of doing their duty well.[4] At the other extreme, the organizational design relies on clear rules and standards with rewards and penalties directly tied to specific achievements of the individual. Notably such more formal incentive systems are intended for low-level bureaucrats (called 'street-level bureaucrats' by Lipsky (1980)) while the upper-levels of the bureaucratic hierarchy relies on professionalism.

We draw on both types of organizational design in this paper. We present a model of a bureaucracy with three layers: a funding authority, an upper-level manager and an agent. The first layer is the funding authority, which may represent the Congress for instance. It has no informational capability, or ability, or time to run the many agencies it funds. In the language of Aghion and Tirole (1997), the funding agency has formal authority but it must relinquish real authority to an upper-level manager – whom we call the bureaucrat – who runs the agency. This bureaucrat herself hires an agent who produces the output. Next we explain that we model the bureaucrat as a professional and the agent as a street-level bureaucrat or procurement firm.

The bureaucrat is a professional who shares, for the most part, the goals of the funding agency, and works without a formal incentive scheme. We recognize that professionalism may sometimes fall short. In the most well-known variation of Niskanen (1971), Migué and Bélanger (1975) assume that the bureaucrat cares about his discretionary budget. The discretionary budget is the difference between the budget and the cost required to produce the output.

While bureaucrats are supposed to return this difference to the funding authority, it is well-known that, when facing an unspent budget, bureaucrats often go

[4] Brehm and Gates (1997) discussing the role of professional standards norms and self-selection that plays an important role write in the preface to their book, "the police officer, the social worker, the NASA engineer, the health inspector chose their jobs not for the possibility of maximizing leisure, or even for the material rewards of the job, but for the intrinsic character of the job itself.", and elsewhere, "Our book offers one answer: bureaucratic accountability depends most of all on the preferences of individual bureaucrats. Fortunately for us, those preferences are overwhelmingly consistent with the jobs the American democracy sets for them to do."

on a “spending spree.” For instance, the end of the fiscal year often witnesses the purchase of new equipment and travel to exotic places for conferences. In the U.S., July marks the start of the last quarter of the fiscal year and this period is known among federal contractors as “Christmas in July.”[5] In 2005, an audit by the U.S. Department of Defense Inspector General denounced the approval of hundreds of millions of dollars on questionable "last-minute" projects.[6] The audit revealed that 74 out of 75 selected purchases scheduled at the end of fiscal 2004 “were either hastily planned or improperly funded.” It also found the department of Defense “parked” $2 billion that were unspent at the end of 2004 in a special account intended for information technology purchases, apparently to keep it out of sight of Congress and so it could be spent later. "They know the money is lost to them if they don't use it," says Eugene Waszily, assistant inspector general at the General Services Administration[7]. While accounting controls should prevent some unnecessary expenses, we will recognize in our model that the unspent budget can be “appropriated” by the bureaucrat and become a discretionary budget.

The discretionary budget allows the bureaucrat to pursue goals different from those of the funding authority. This is known as “policy drift” (Libecap (1986)) and is distinct from standard shirking. The discretionary budget, also known as “slack,” is sometimes seen as the “bureaucratic equivalent of personal income” (Moe 1997). We capture this policy drift by including the discretionary budget in the bureaucrat’s objective function.

The agent can either be a procurement firm or a street-level bureaucrat. The procurement firm has private information about its production cost and must be given an incentive scheme to limit its information rent. The procurement problem has received much attention in economics (see, e.g., Laffont and Tirole (1993)). Our contribution is to analyze a procurement contract offered by a bureaucrat operating under a fixed budget with a policy drift.

The agent could also be seen as a street-level bureaucrat, who is not a professional and requires a formal incentive scheme. Street-level bureaucrats may have conflicting preferences with the upper management (our bureaucrat). For

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[5] Wall Street Journal editorial, “Christmas in July,” July 19, 2006.
[6] Department of Defense Office of the Inspector General (2005), http://www.dodig.osd.mil/Audit/reports/FY05/05-096.pdf
[7] Wall Street Journal editorial, “Christmas in July,” July 19, 2006

example, Heckman, Smith, and Taber (1996) present a detailed empirical study of the Job Training Partnership Act (JTPA) of 1982. They find that case workers (street level bureaucrats) in JTPA training centers were motivated to help the less employable participants even though it decreased the performance measure of the training center and the middle manager (bureaucrat). As Dixit (2002) notes, perhaps the bureaucrat *"should have devised an incentive scheme to induce truthful revelation of information by the case workers."* [8]

Agency models have been used to analyze bureaucracies, but key elements of the environment have not received much attention. In this paper, we open up the modeling of the production process. A bureaucrat, armed with a fixed budget and influenced by a policy drift, contracts with another agent (public servant or private) to produce output. This allows us to look at the impact of the budget rules on incentives in bureaucracies. The funding authority needs to understand how the bureaucrat will distort the contract offered to the agent.

One expected result is that the bureaucrat will want to overproduce, but, in addition, we show that a fixed budget can have a dramatic effect on the structure of incentive contracts. More specifically, we show that underfunded bureaucracies will optimally lower the power of incentives. Furthermore, the more professional the bureaucrat (i.e., a bureaucrat who less cares about policy drift), the weaker the power of incentives. We also show that the bureaucrat even offers in equilibrium a pooling contract that nullifies the power of incentives if she is more professional and/or if the budget is tighter. Despite lowering the power of incentives, our results suggest that the funding authority will always give a budget that is smaller than what the bureaucrat desires.

Although we focus on government bureaucracy, our model can also apply to large private corporations. The fiscal rule of a fixed budget that has to be returned if unspent is also common in the private sector where large firms are organized similarly. Jack Welch, former CEO of General Electric, once described this with his often quoted statement: "The budget is the bane of corporate America." (Fortune Magazine 1995) Private firms tend to be more flexible with budget as they do not

[8] "One can easily imagine similar task idiosyncrasies in public bureaucracies: regulators who understand the ways in which polluting, firms disguise their transmissions of toxins, police officers who have a sense of when community tensions are peaking, or social workers who are personally familiar with the work records of their clients" (Gates and Brehm (1997) pp 16).

have to follow strict administrative rules of public bureaucracies. Still it is common for private companies to operate with fixed budgets for their various departments and the rule that unspent budget are lost at the end of the fiscal year. With various means and ways, the departments end up spending the unspent budget as the fiscal year moves toward its end.

The fixed budget constraint can be seen as a form of “upper limited liability.” The limit on contingent transfers that the bureaucrat can offer in a contract is akin to Levin’s (2003) constraint of limited compensation imposed by self-enforcement. Levin studies self-enforced relational contracts and shows that self-enforcement restricts promised compensation. The interaction between this upper limited liability and the traditional limited liability of the agent has dramatic effects on the incentive contract. As in Levin we also find that hidden information models may involve pooling when both sides (principal and agent) have limited resources.

The professionalism of the bureaucrat, which reflects the congruence of preference between the bureaucrat and the authority, has also been noted in recent papers by Prendergast (2007), and Besley and Ghatak (2005). They have pointed out that agents in public office or in private not-for-profit firms are often intrinsically motivated to deliver goods or services they are engaged to produce. Although these papers are otherwise quite different, the degree of congruence of preference plays an important role just like the parameter k in our model.

We present a model of bureaucracy with a funding authority, a bureaucrat, and an agent in section 2. After characterizing the contract a bureaucrat will offer an agent in section 3, we study the funding authority’s problem in section 4 to show that there will be low powered incentives in a bureaucracy. We conclude in section 5.

2. The model

We consider a three level hierarchy with hidden information: a funding authority (it), a bureaucrat (she) and an agent (he), where the agent has private information about production cost. The funding authority could be the legislature, which is interested in the production of some output but does not have the time or the ability to manage the agent who runs the production process. It delegates the task to the bureaucrat and provides her with a fixed budget, denoted by B, independent of the output produced. The bureaucrat has expertise to contract with the agent and can offer an incentive contract to the agent.

The agent is the productive unit in the hierarchy. He produces an output, denoted by $X \geq 0$, at cost $C(X) = \frac{c}{2}X^2$, where $c > 0$. The constant c is private information of the agent and represents his type. It can take two values c_L with probability q_L and c_H with probability q_H (with $c_H > c_L$ and $q_L + q_H = 1$). The bureaucrat offers a contract to the agent specifying the output (X_L or X_H) and a contingent transfer (t_L or t_H).

The bureaucrat receives a fixed budget B from the funding authority and uses it to fund an incentive contract for the agent. As argued in the introduction, the bureaucrat is a professional who shares the funding authority's goals to a large extent, but also values any unspent budget, either as a discretionary budget to spend on bureaucratic perks or as "policy-drift". We capture this by the following objective function for the bureaucrat:[9]

(1) $$q_L X_L + q_H X_H + k[B - q_L t_L - q_H t_H],$$

where k is a congruence parameter, which puts a value for the bureaucrat on any unspent budget. It will play a critical role in our model since the congruence parameter k captures the difference in objectives between the bureaucrat and the funding authority. If $k = 1$, they have identical relative valuations of output and unspent budget, and in the paper we focus on the case $k \leq 1$.[10] If $k = 0$, the bureaucrat only cares about the output – she is the "ultimate professional" like an environmentalist running the EPA or a school teacher running the department of education. Unlike the funding authority, she does not care about the cost of raising the budget to run the bureaucracy. So a lower k represents a more professional bureaucrat.

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[9] There are several ways to think about what the bureaucrat does with the unspent budget, and thus how she values it. In this section, we ignore the interpretations and simply model the value of the unspent budget with an exogenous congruence parameter k. We return to this issue in section 4, where we also consider the funding authority's ability to vary k, for example by changing accounting controls or setting up legislative oversight committees.

[10] Depending on whether k is greater or less than one, the bureaucrat will want to over or underproduce relative to the second best. Here we focus on the issue of over-production by assuming $k \leq 1$.

The assumption that the funding authority gives the bureaucrat a fixed budget makes our modeling novel to the standard procurement problem of Laffont and Tirole (1993). If the funding authority could vary the budget according to output, our model would boil down to a standard adverse selection model.

We assume that the funding authority does not observe the details of the incentive contract. As argued in the introduction, the funding authority is not able to measure with precision the output produced. If it could, it would also know the amount of any unspent budget and easily prevent misdirected spending by the bureaucrat.

The timing of the game is as follows: the funding authority presents the bureaucrat with a fixed budget B. Next, the bureaucrat offers an incentive contract to the agent specifying the output (X_L and X_H) expected from each type of agent as well as the corresponding transfers (t_L and t_H). We assume that the agent learns his type before signing this contract and therefore we have a model of adverse selection. Next, production takes place and the appropriate contingent transfer is given to the agent.

In her maximization problem, the bureaucrat faces the following incentive constraints,

$$\left(IC_i\right) \quad t_i - \frac{c_i}{2} X_i^2 \geq t_j - \frac{c_i}{2} X_j^2 \qquad \text{for } i, j = L, H,$$

along with the participation constraints,

$$\left(IR_i\right) \quad t_i - \frac{c_i}{2} X_i^2 \geq 0 \qquad \text{for } i = L, H,$$

and the budget constraints,

$$\left(BG_i\right) \quad t_i \leq B \qquad \text{for } i = L, H .$$

(IC_i) and (IR_i) are standard constraints in a model of adverse selection, and (BG_i) is the budget constraint limiting the transfers to the agent by the budget B available to the bureaucrat. As benchmarks, we derive the first-best and the second-best cases. In the first-best case, the principal directly contracts with an agent under full information. The first best (FB) contract requires that the agent of type i ($i = L$ or H) produces $X_i^{FB} = \frac{1}{c_i}$ and receives a transfer $t_i^{FB} = \frac{c_i}{2}\left(X_i^{FB}\right)^2$. In the second best case, again the principal directly contracts with an agent but under asymmetric information. This means the principal maximizes (1), where $k = 0$, such that (IC_i) and (IR_i), for $i = L, H$, are satisfied. The second best (SB) contract is a menu:

$$\left\{\left[X_L^{SB} = \frac{1}{c_L};\ t_L^{SB} = \frac{c_L}{2}\left(X_L^{SB}\right)^2 + \frac{\Delta c}{2}\left(X_H^{SB}\right)^2\right], \left[X_H^{SB} = \frac{1}{\left(c_H + \frac{q_L}{q_H}\Delta c\right)};\ t_H^{SB} = \frac{c_H}{2}\left(X_H^{SB}\right)^2\right]\right\}$$

with $\Delta c = c_H - c_L$.

This is a standard second best contract with the efficient type producing at the first best level and obtaining a rent while the inefficient type has his output distorted and receives no rent. Note also that $t_H^{SB} \leq t_L^{SB}$. That means that a fixed budget covering the transfer to the low-cost agent would be partially unspent when the cost is high. In the next section, we present the bureaucrat's problem of deriving an optimal incentive scheme for the agent given B and k.

3. The Bureaucrat's Problem

We begin our main analysis with the bureaucrat's problem taking as given the budget B from the funding authority. The bureaucrat maximizes (1), such that (IC_i), (IR_i), and (BG_i), for $i = L, H$, are satisfied.

Note that this problem is different from the second best in two ways: the objective function (1) includes two new parameters, k and B, and there are two new budget constraints (BG_i). Only if neither budget constraints are binding and $k = 1$, will we get the second best contract to be optimal. Thus, there are two sources of departures from the second best, those implied by a binding budget, and those implied by $k < 1$. A binding budget may prevent the bureaucrat from having enough resources to implement the second best even if $k = 1$. If $k < 1$, the bureaucrat's marginal value of money is smaller than the funding authority's, so she will value output relatively more than the funding authority. The divergence of objectives between the funding authority and the bureaucrat regarding the relative value of money will lead to the budget being binding. The analysis of this interaction between k and a binding budget is the focus of our paper.

This interaction leads to new considerations in characterizing optimal incentive schemes. Since $t_L \geq t_H$ in equilibrium, increasing X_L involves an additional cost implied by a tighter budget constraint over and above the standard production cost. This makes X_L less attractive to the bureaucrat than in the standard case. As a result, the typically ignored (IC_H) becomes relevant in our model since otherwise X_L may fall below X_H. However, to make the exposition simpler, we replace (IC_H) by the following monotonicity condition:

(M) $\quad X_L \geq X_H$.

Indeed, we can verify ex post that (IC_H) is satisfied by our optimal contract.[11]

As usual, we can ignore (IR_L) since it is implied by (IR_H) and (IC_L), and given $X_L \geq X_H$, the constraint (IC_L) implies that $t_L \geq t_H$. Therefore, the budget constraint (BG_H) will be satisfied if the constraint (BG_L) holds. Based on these arguments, we can present the bureaucrat's problem using only the relevant constraints. The bureaucrat chooses the contract $\{X_L, X_H, t_L, t_H\}$ to solve the problem given below, denoted by ***BP***:

$$
\begin{aligned}
& Max\, q_L X_L + q_H X_H + k\left(B - q_L t_L - q_H t_H\right) \\
& s.t., \quad (IR_H) \quad t_H - \frac{c_H}{2} X_H^2 \geq 0, \\
& \qquad (IC_L) \quad t_L - \frac{c_L}{2} X_L^2 \geq t_H - \frac{c_L}{2} X_H^2, \\
& \qquad (BG_L) \quad t_L \leq B, \\
& \qquad (M) \quad X_L \geq X_H.
\end{aligned}
$$

First note that the (IR_H) and (IC_L) are binding since otherwise the bureaucrat could reduce the transfers and gain. Substituting t_L and t_H using the binding (IR_H) and (IC_L), we can write the Lagrangian as follows:

$$
\begin{aligned}
L = q_L X_L + q_H X_H + k\left[B - q_L\left(\frac{c_L}{2} X_L^2 + \frac{\Delta c}{2} X_H^2\right) - q_H \frac{c_H}{2} X_H^2\right] \\
+ \lambda\left[B - \left(\frac{c_L}{2} X_L^2 + \frac{\Delta c}{2} X_H^2\right)\right] + \mu(X_L - X_H),
\end{aligned}
$$

where $\Delta c = c_H - c_L$, and $\lambda \geq 0$, $\mu \geq 0$ are the Lagrange multipliers. The two first-order conditions with respect to the outputs are:

[11] It is easy to check that a binding (IC_L) and (M) imply that (IC_H) holds.

(2) $$\frac{\partial L}{\partial X_L} = q_L - \left(kq_L c_L + \lambda c_L\right) X_L + \mu = 0\,,$$

(3) $$\frac{\partial L}{\partial X_H} = q_H - \left(kq_H c_H + kq_L \Delta c + \lambda \Delta c\right) X_H - \mu = 0\,.$$

There are several cases to analyze, which we do in turn. It is easy to see that if the budget is not binding ($\lambda = 0$) but $k > 0$, the optimal contract would always be a separating contract, i.e., a contract where the outputs and transfers are distinct for each type.[12] The bureaucrat increases the output until the marginal value of output equals the marginal cost (including information rent) evaluated at rate k. Because their marginal costs are different, the bureaucrat asks different outputs to different agents by offering a separating contract. The optimal contract is very similar to the second-best contract identified above and would be identical if $k = 1$; for $k < 1$, the outputs would be larger than X^{SB}.[13]

When the budget is binding ($\lambda > 0$), there is a potential for the monotonicity condition (M) to become binding since increasing X_L will entail an extra cost due to an increase in the transfer t_L and tightening of the budget constraint. If (M) is binding, $\mu > 0$ and pooling occurs ($X_L = X_H$). We obtain the condition for pooling by setting $\mu = 0$ in the first order conditions (2) and (3) and seeing when the monotonicity condition (M) is violated:

$$\begin{aligned} & X_L \le X_H, \\ & \Leftrightarrow \quad q_H\left(kq_L c_L + \lambda c_L\right) \ge q_L\left(kq_H c_H + kq_L \Delta c + \lambda \Delta c\right), \\ (P) \quad & \Leftrightarrow \quad \lambda\left(q_H c_L - q_L \Delta c\right) \ge kq_L \Delta c. \end{aligned}$$

As is well known, pooling is not optimal in a standard two-type model, which is also true in our model when the budget is not binding, i.e., $\lambda = 0$. Thus, pooling can only occur if the budget is binding ($\lambda > 0$), which is obvious in condition (P).

If condition (P) holds, we have $X_L = X_H$, and the binding (IC_L) implies that $t_L = t_H$, with each type obtaining an identical contract. The optimal output and transfer

[12] Note that the budget must be binding if $k = 0$. When $k = 0$, the bureaucrat cannot benefit from unspent budgets. She only cares about the output and will want to spend the entire budget. Technically, if $k = 0$, the first order conditions (2) and (3) imply that $\lambda > 0$, meaning that the budget constraint is binding.
[13] Use $\lambda = 0$ in (5) to get X^{SB}.

in the pooling contract, denoted by (X^P, t^P) can be derived by using (IR_H) in the binding budget constraint:

$$(4) \qquad B - \frac{c_H}{2}\left(X^P\right)^2 \equiv 0, \text{ and } t^P = B.$$

Interestingly, this contract appears to ignore incentives, i.e., it requires a constant output, X^P, irrespective of the actual cost of production. This can be, however, the optimal incentive contract. Under a fixed budget, the bureaucrat may find it optimal to offer a flat incentive scheme to the agent.

Since pooling can only occur if the budget is binding ($\lambda > 0$ in (P)), each type of agent receives the entire budget, and there is no unspent budget under pooling. The parameter k plays no role since there is no unspent budget in the hands of the bureaucrat, and X^P is independent of k. Furthermore, we observe that X^P increases with B. We can present some additional intuition about details of condition (P) once we have analyzed the separating contract, which we move to next.

A key benefit to the bureaucrat from offering a separating contract is the unspent budget. Unless she is interested in this unspent budget, the bureaucrat will not offer a separating contract. Thus, for separation to be optimal, it is necessary to have a high enough k, which can be seen in condition (P) also.

If condition (P) does not hold, the optimal contract is separating, which can be derived using $\mu = 0$ in (2) and (3) and the binding (IC_L) and (IR_H) constraints:

$$(5) \left\{\left[X_L^S = \frac{q_L}{kq_Lc_L + \lambda c_L};\ t_L^S = B\right], \left[X_H^S = \frac{q_H}{k\left(q_Hc_H + q_L\Delta c\right) + \lambda\Delta c};\ t_H^S = \frac{c_H X_H^{S\,2}}{2}\right]\right\},$$

where λ is obtained from the binding budget constraint:

$$(BG^S) \quad B = \left(\frac{c_L}{2}\left(X_L^S\right)^2 + \frac{\Delta c}{2}\left(X_H^S\right)^2\right).$$

The condition (P) also provides a necessary condition for pooling, which is can be presented as:

$$(NP) \quad q_Hc_L - q_L\Delta c \geq 0.$$

This necessary condition (NP) is best explained by considering the case where $k = 0$, where the bureaucrat is only interested in expected output. If separation is optimal when $k = 0$, then it will continue to be optimal for $k > 0$ since then the bureaucrat has the additional incentive to offer separation in order to appropriate the unspent budget. Looking at (2) and (3) when $k = 0$ immediately tells us that separation is optimal if and only if (*NP*) *does not* hold. In this case, payments to the agent are not directly relevant to the bureaucrat, but only expected output and the budget constraint (*BG*) matter. An increase in X_L affects (*BG*) via cost c_L and X_H affects (*BG*) via rent Δc. Since the marginal benefits are q_L and q_H, we have X_L greater than X_H (when $k = 0$) if and only if $q_L/c_L > q_H/\Delta c$.

We gather in proposition 1 the results proven so far, and then analyze in detail the separating contract.

Proposition 1: *If the budget constraint is not binding, it is optimal for the bureaucrat to offer a separating contract (5). If the budget constraint is binding, then offering a pooling contract (4) is optimal if condition (P) holds; otherwise, a separating contract (5) is optimal.*

The optimal separating contract has some familiar features to the second best contract. The efficient agent (low cost) produces more than the inefficient agent ($X_L > X_H$) and obtains a rent. The inefficient agent receives no rent. However, there are some new features implied by the presence of k and a fixed B. With $k > 0$, since only the inefficient agent does not consume the entire budget, the bureaucrat is interested in limiting X_H to increase the unspent budget. When the budget is binding, $B = t_L$, and since $t_L = (c_L/2)X_L^2 + (\Delta c/2)X_H^2$, there is an additional cost of increasing the outputs captured by the terms associated with the shadow price of the budget λ in (2) and (3). This additional cost will turn out to be key to understanding the implications on the power of incentives, defined as the ratio of outputs X_L/X_H, and to understand when pooling is likely to occur.

We begin by examining the new features implied by changes in k, the value of the unspent budget to the bureaucrat. It is intuitive that an increase in k makes the budget constraint less tight (λ falls) since the bureaucrat is now less interested in output.[14] However, as can be seen from (5), the impact of k on the outputs is still hard to decipher. The interaction is subtle and is based on the key insight that, given a fixed B, the bureaucrat can increase the unspent budget only by reducing X_H. Therefore, she lowers X_H if her preference for the unspent budget k increases. The reduction of X_H implies that the rent to the L-type decreases, which allows her to increase X_L and pursue her twin objective of obtaining high output. Therefore, the power of incentives increases with k. In other words, the bureaucrat offers a strong incentive scheme because she knows she will be able to benefit from the unspent budget.[15]

Also, from the binding budget constraint (BG^S) it is immediate that the two outputs are inversely related for a given budget. Since the power of incentives increases with k, bureaucracies will tend to have lower powered incentives if bureaucrats are more professional.

It may seem counterintuitive that the power of incentives increase with k as the parameter also represents the opportunity cost of unspent budget. Note however, that the expected output, denoted by $E[X^S]$ falls with k. When the bureaucrat values the unspent budget more, the expected output falls. Since the cost functions are convex, more dissimilar output levels (making X_L/X_H larger) would violate the fixed budget unless the expected output is reduced. Then $E[X^S]$ decreases with k since X_L/X_H increases with k. Our model suggests a new argument why bureaucracies may find lower-powered incentives optimal: the lower value of money for the bureaucrat under the constraint of fixed budgets.

Therefore, bureaucracies with more professional bureaucrats produce higher output. However, professionals only care about output and don't consider the cost of raising funds. The funding authority controls professionals with fixed budgets.

These results are summarized in proposition 2.

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[14] Indeed, we prove in the appendix that $\dfrac{\partial \lambda}{\partial k} < 0$.

[15] We formally prove in the appendix that $\dfrac{\partial X_H}{\partial k} < 0$ and $\dfrac{\partial X_L}{\partial k} > 0$, and therefore, $\dfrac{\partial}{\partial k}\left(\dfrac{X_L}{X_H}\right) > 0$.

Proposition 2: *In a separating equilibrium, i.e., when (P) does not hold, the more professional the bureaucrat (smaller k), the higher the output and the weaker the power of incentives. In a pooling equilibrium, the outputs are independent of k.*

Proof: In the Appendix.

Assuming that the necessary condition for pooling (*NP*) holds strictly, we illustrate the output levels with respect to k in Figure 1. Consider first the extreme case where $k = 0$. ,A pooling contract is optimal as the bureaucrat places no value on the unspent budget. As k increases, the bureaucrat moves from offering a pooling to a separating contract, which happens at the critical value of $k \equiv k_T$, and we have $X^P = X_L^S = X_L^S$ when $k = k_T$.[16] For higher values of k, the bureaucrat decreases the expected output as she put more value on the unspent budget. To summarize, the bureaucrat continues with pooling until k_T since the higher pooling output is more attractive than the relatively small budget-surplus, and only introduces separation when the value of the unspent budget outweighs the loss in expected output.

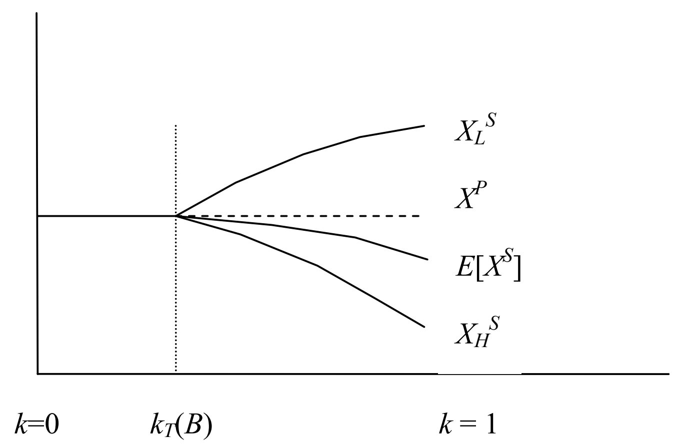

Figure 1. Changes in the optimal outputs as a function of k assuming (*NP*) holds strictly.

[16] The cut-off k_T is defined by $\lambda(B, k_T)(q_H c_L - q_L \Delta c) \equiv k_T q_L \Delta c$. From this, given $q_H c_L > q_L \Delta c$, $k_T > 0$ if $\lambda > 0$. Indeed, as k goes to zero, we must have $\lambda > 0$ by (5). Otherwise X_L and X_H would become unbounded which is impossible given a fixed budget. Therefore (*P*) is strictly satisfied for k small enough.

Of course the critical value k_T depends on the budget, and we note that $\frac{\partial k_T}{\partial B} < 0$.[17] As B increases, the potential gain from the unspent budget (kq_H (B–t_H)) increases as well because t_H increases but by less than the increase in B. Thus, the bureaucrat begins to offer a separating contract earlier (small k) for larger budgets.

We now examine the new features implied by changes in the budget B. Since an increase in B relaxes the budget constraint (BG) and lowers its shadow value, λ, it is easy to note from (5) that both outputs increase with the budget, $\frac{\partial X_L^S}{\partial B} > 0$ and $\frac{\partial X_H^S}{\partial B} > 0$. When offered a larger budget the bureaucrat can generate higher outputs by using larger transfers. The more interesting issue is the power of incentives, i.e., the ratio of outputs. The bureaucrat increases X_L more than X_H and $\frac{\partial}{\partial B}\left(\frac{X_L}{X_H}\right) > 0$, i.e., the power of incentives increases with a larger budget. This is the result of a compromise between the two objectives of the bureaucrat: increasing output and retaining some unspent budget. When k = 0, the ratio of X_L to X_H is constant across different levels of B. However, if k > 0, the bureaucrat not only cares about the expected output but also the unspent budget. To take both into account, the bureaucrat increases X_L more than X_H given an increase in B. Therefore, our model suggests a new argument why bureaucracies may find lower-powered incentives optimal: under-funded agencies operating with a fixed budget. An agency facing a small fixed budget will offer low powered incentives. At the extreme, if B is small enough, all incentives are removed, the ratio X_L/X_H = 1, and we have a pooling contract.

Proposition 3: *Under-funded bureaucracies offer low powered incentives.*

Proof: In the Appendix.

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[17] From $\lambda(B,k_T)(q_H c_L - q_L \Delta c) \equiv k_T q_L \Delta c$, $\frac{\partial k_T}{\partial B} = -\left[\frac{\partial \lambda}{\partial k}(q_H c_L - q_L \Delta c) - q_L \Delta c\right]^{-1} \frac{\partial \lambda}{\partial B}$. As shown in the proofs of propositions 1 and 2, $\frac{\partial \lambda}{\partial k} < 0$ and $\frac{\partial \lambda}{\partial B} < 0$. Thus, given $q_H c_L - q_L \Delta c$, $\frac{\partial k_T}{\partial B} < 0$.

Again assuming the necessary condition (*NP*) holds strictly, we show in figure 2 how the outputs change with B. For small budgets, the bureaucrat offers a pooling contract. As the budget increases, the bureaucrat will eventually offer a separating contract to enjoy the unspent budget and the power of incentives will increase.

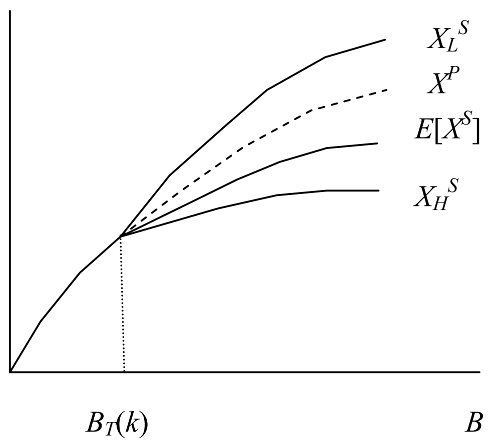

Figure 2. Changes in the optimal outputs as a function of *B* assuming (*NP*) holds strictly.

B_T is the critical budget level dividing the pooling and separating regions.[18] Since the pooling condition also depends on *k*, the critical B_T also depends on *k*, and we can derive $\frac{\partial B_T}{\partial k} < 0$.[19] With a higher *k*, the bureaucrat benefits more from the unspent budget. Since only separating contracts generate unspent budget, the bureaucrat's preference for separating contracts increases with *k*.

Having established how the power of incentives is affected by the two key parameters, we can state when pooling is likely. The power of incentives falls as *B* and *k* decrease and the outputs come closer to each other. A smaller budget or a stronger preference for output, both imply a tighter budget constraint (λ increases),

[18] The parameter B_T is defined by $\lambda(B_T, k)\left(q_H c_L - q_L \Delta c\right) \equiv k q_L \Delta c$. Given $q_H c_L > q_L \Delta c$, $B_T(k) > 0$. As B goes to 0, (BG^S) implies that both outputs must go to zero, which is only true if λ becomes unbounded (see (5)). But then, (P) must be satisfies as a strict inequality since all other variables are bounded.

From $\lambda(B_T, k)\left(q_H c_L - q_L \Delta c\right) \equiv k q_L \Delta c$, $\frac{\partial B_T}{\partial k} = \left[\frac{\partial \lambda}{\partial B}\right]^{-1}\left[q_L \Delta c - \frac{\partial \lambda}{\partial k}\left(q_H c_L - q_L \Delta c\right)\right]$. As shown in the proofs of propositions 1 and 2, $\frac{\partial \lambda}{\partial k} < 0$ and $\frac{\partial \lambda}{\partial B} < 0$. Thus, given $q_H c_L - q_L \Delta c$, $\frac{\partial B_T}{\partial k} < 0$.

which makes it more likely that the pooling condition (*P*) will be satisfied. However, unless the necessary condition (*NP*) holds, pooling will not occur since the monotonicity condition (*M*) will not be violated. The condition (*NP*) determines if the bureaucrat prefers a pooling contract when $k = 0$, i.e., when she is only interested output. If not, then for higher k she will surely not violate (*M*) since her preference for the unspent budget increases with k, and only a separating contract will yield an unspent budget.

For large values of k, the bureaucrat cares more about the unspent budget, which can be enjoyed only if she offers a separating contract. In contrast, for small values of k, the bureaucrat cares more about output levels and offers a pooling contract whose output is greater than the output under a separating contract for a given budget. Similarly, given a large B, the bureaucrat can afford to create a large unspent budget, which is only possible under separation. For a small B, the bureaucrat focuses only on expected output by offering a pooling contract which does not leave any unspent budget. These results are summarized in the next proposition.

Proposition 4: *Given that the necessary condition for pooling* (*NP*) *holds, pooling is more likely to occur for small budgets and if the bureaucrat is more professional (small k)*.

Proof: In the Appendix.

We have studied the bureaucrat's response to a given B and k. In the next section, we discuss the funding authority's problem when choosing the bureaucrat's budget.

4. The funding authority's preference over *k* and *B*

In section 3, we characterized the optimal contract a bureaucrat would offer an agent given a fixed budget. We found that both increases in B and k result in higher powered incentives, but the two parameters differ in their impact on expected output. Expected output increases with B, but it decreases with k because a stronger preference for unspent budget means the bureaucrat finds output less attractive. In this section, we will discuss the funding authority's problem anticipating the optimal contract offered by the bureaucrat for different values of B and k. We will argue next that the funding authority will always choose the offer a budget that is binding for the bureaucrat and offer relatively smaller budget for less professional bureaucrats. .

A key contribution in our modeling of a bureaucracy lies in how the bureaucrat values unspent budget The higher the value of the unspent budget, whether due to a higher k or a larger B, the stronger the incentives. Such incentives become close to the levels provided in the second best contract, i.e., when the principal does not need to rely on a bureaucracy to contract with the agent. This is consistent with the popular notion about the burden of bureaucracies. If the principal has a higher value of unspent budget than a bureaucrat, he is more careful in providing incentives to take advantage of opportunities, e.g., produce more when the cost is low. Then, we expect that a bureaucrat less constrained by a fixed budget and who has more discretion over the unspent budget will behave more like a principal.

There is a difference between the funding authority's and the second best problem even if $k = 1$. In this extreme case, the bureaucrat and the authority have identical relative values of money, and the bureaucrat would implement the second best outputs given a large enough budget. The unspent budget, however, poses a problem.[20] Since it must give a fixed budget, the authority is not able to save money when the cost is high, which it would be able to do if it were able to contract directly with the agent. Therefore, the authority would give a lower budget to the bureaucrat than the amount necessary to implement the second best outputs even if we had $k = 1$. For the bureaucrat, then, the budget constraint would be binding. If $k < 1$, then the bureaucrat would overproduce relative to the second best (because her relative value of money is less than the authority's) and the authority would again give her a smaller budget such that the constraint is binding. Therefore, the budget constraint is always binding in the bureaucrat's problem and the power of incentives is lower in a bureaucracy than in the second-best benchmark. These results are summarized in the following proposition.

[20] We assume that the authority does not benefit from however the unspent budget is used. This does not necessarily mean the money is 'stolen'. It may be used to produce output that the bureaucrat values, e.g., research in a teaching college, but the Administration does not value.

Proposition 5. *The funding authority will offer a budget such that the budget constraint is binding for the bureaucrat, which implies that bureaucracies will have lower powered incentives than in the standard (second-best) case.*

Proof. In the Appendix.

Note that a contract with strong incentives is not necessarily a good thing for the authority as long as budgets are fixed. With a fixed budget, stronger incentives are associated with large unspent budgets, that are costly for the funding authority,. Furthermore, the authority knows that for higher values of k the bureaucrat offers a stronger incentive scheme so as to increase the amount of unspent budget but at the cost of lower expected output. Therefore, the funding authority curtails the bureaucrat's ability to engage in policy drift by lowering the budget when k increases.

5. Conclusions

Bureaucrats who operate under the budget rule "use it or lose it" are expected to return any unspent budget at the end of a fiscal year. Instead, they tend to view unspent budgets as discretionary and go on spending sprees towards the end of the fiscal year even though much of the expenses are not in the interest of the funding authority. This phenomenon is known as policy drift. Sometimes, bureaucrats even "park" the unspent budget in "no year" accounts. Staffers from the Homeland Security and Government Affairs Subcommittee on Federal Financial Management, Government Information, and International Security estimated such amount to be $376 billion in 2006.[21]

In this paper, we showed how fixed budgets and policy drift imply that the optimal incentive contract of an agent employed in a bureaucracy will be low powered. In our model, this occurs due to the non-congruence of preferences between the funding authority and the bureaucrat working under a fixed budget, which is different from typical explanations for low-powered incentives in bureaucracies. We showed that bureaucrats who have small budgets or who have a lower policy drift tend to provide relatively low power inventive schemes. In response to these distorted incentives, the funding authority will provide bigger budgets to bureaucrats with less

21 http://coburn.senate.gov/ffm/index.cfm?FuseAction=LatestNews.NewsStories&ContentRecord_id=1f90396c-802a-23ad-4386-174142756310

policy drifts. A possible testable implication of our model is that agencies with lower policy drift should have bigger budget but low power incentive schemes.

Appendix

Proof of proposition 2

Given that $X_L > X_H$ (separating contracts) and therefore $\mu = 0$, the Lagrangian for the bureaucrat's problem is

$$L = q_L X_L + q_H X_H + k\left[B - q_L\left(\frac{c_L}{2}X_L^2 + \frac{\Delta c}{2}X_H^2\right) - q_H\frac{c_H}{2}X_H^2\right] + \lambda\left[B - \left(\frac{c_L}{2}X_L^2 + \frac{\Delta c}{2}X_H^2\right)\right]$$

where λ is the Lagrangian multiplier associated with the budget constraint. The solution (X_L^S, X_H^S) to this problem satisfies the following first-order conditions:

(A1) $$\frac{\partial L}{\partial X_L} = q_L - \left(kq_L c_L + \lambda c_L\right)X_L^S = 0,$$

(A2) $$\frac{\partial L}{\partial X_H} = q_H - \left(kq_H c_H + kq_L\Delta c + \lambda\Delta c\right)X_H^S = 0,$$

(A3) $$\frac{\partial L}{\partial \lambda} = B - \frac{c_L}{2}\left(X_L^S\right)^2 - \frac{\Delta c}{2}\left(X_H^S\right)^2 = 0.$$

The derivatives of the first-order conditions with respect to k can be expressed as

(A4) $$-\alpha_0 - \alpha_1\frac{\partial\lambda}{\partial k} - \alpha_2\frac{\partial X_L^S}{\partial k} = 0,$$

(A5) $$-\beta_0 - \beta_1\frac{\partial\lambda}{\partial k} - \beta_2\frac{\partial X_H^S}{\partial k} = 0,$$

(A6) $$-\gamma_1\frac{\partial X_L^S}{\partial k} - \gamma_2\frac{\partial X_H^S}{\partial k} = 0,$$

where $\alpha_0 = q_L c_L X_L^S$, $\alpha_1 = c_L X_L^S$, $\alpha_2 = kq_L c_L + \lambda c_L$, $\beta_0 = (q_H c_H + q_L \Delta c) X_H^S$, $\beta_1 = \Delta c X_H^S$, $\beta_2 = kq_H c_H + kq_L \Delta c + \lambda \Delta c$, $\gamma_1 = c_L X_L^S$, $\gamma_2 = \Delta c X_H^S$, and all of these coefficients are positive. From these, solving for $\frac{\partial \lambda}{\partial k}$ gives

(A7) $$\frac{\partial \lambda}{\partial k} = -\frac{\alpha_0 \beta_2 \gamma_1 + \alpha_2 \beta_0 \gamma_2}{\alpha_1 \beta_2 \gamma_1 + \alpha_2 \beta_1 \gamma_2} < 0 .$$

From (A1) and (A2), $\frac{X_L^S}{X_H^S} = \frac{q_L\left(kq_H c_H + kq_L \Delta c + \lambda \Delta c\right)}{q_H\left(kq_L c_L + \lambda c_L\right)}$. Then,

(A8) $$\frac{\partial}{\partial k}\left(\frac{X_L^S}{X_H^S}\right) = \frac{q_L c_H c_L}{\left(kq_L c_L + \lambda c_L\right)^2}\left(\lambda - k\frac{\partial \lambda}{\partial k}\right) > 0$$

because $\frac{\partial \lambda}{\partial k} < 0$ from (A7).

Let define $g \equiv \frac{X_L^S}{X_H^S}$. Then (A3) becomes $B - \frac{c_L g^2 + \Delta c}{2}\left(X_H^S\right)^2 = 0$. From this, $X_H^S = B^{\frac{1}{2}}\left(\frac{2}{c_L g^2 + \Delta c}\right)^{\frac{1}{2}}$. Then

(A9) $$\frac{\partial X_H^S}{\partial k} = -B^{\frac{1}{2}} 2 c_L g \left(\frac{2}{c_L g^2 + \Delta c}\right)^{\frac{1}{2}} \frac{\partial g}{\partial k} < 0$$

because $\frac{\partial g}{\partial k} > 0$ from (A8). Then, (A6) and (A9) imply that

(A10) $$\frac{\partial X_L^S}{\partial k} > 0 .$$

Finally, we prove that $\frac{\partial E[X^S]}{\partial k} < 0$. Denote the optimal outputs by X' for $k = k'$, with $X_L' > X_H'$. Let k increase by a small amount to k''. An increase in k implies that X_L increases to X_L'' and X_H decreases to X_H''. The bureaucrat's objective function is $E[X^S] + kq_H(B - c_H X_H^2/2)$. Thus the second term increases with k, and we claim that the first term $E[X^S]$ must fall. Suppose not. Then the outputs X_i'' yield a higher payoff than X' to the bureaucrat with k', which is a contradiction. This is because the outputs X_i'' are feasible under k' (because both X' and X'' satisfy the budget constraint with the same budget), but not chosen. Therefore both terms could have been increased by choosing X_i'', which means that X_i' could not have been optimal.

Proof of proposition 3

Taking derivatives of the first-order conditions in (A1) – (A3) with respect to B gives

(A11) $$-\alpha_1 \frac{\partial \lambda}{\partial B} - \alpha_2 \frac{\partial X_L^S}{\partial B} = 0,$$

(A12) $$-\beta_1 \frac{\partial \lambda}{\partial B} - \beta_2 \frac{\partial X_H^S}{\partial B} = 0,$$

(A13) $$1 - \gamma_1 \frac{\partial X_L^S}{\partial B} - \gamma_2 \frac{\partial X_H^S}{\partial B} = 0,$$

where all coefficients α, β, and γ are positive and defined in the proof of proposition 1. From (A11) and (A12), $\frac{\partial X_L^S}{\partial B} = \frac{\alpha_1 \beta_2}{\alpha_2 \beta_1} \frac{\partial X_H^S}{\partial B}$, implying that $\frac{\partial X_L^S}{\partial B}$ and $\frac{\partial X_H^S}{\partial B}$ have the same sign. Then, from (A13) it must be that $\frac{\partial X_L^S}{\partial B} > 0$ and $\frac{\partial X_H^S}{\partial B} > 0$, implying that

(A14) $$\frac{\partial \lambda}{\partial B} < 0,$$

from (A11) or (A12). Finally, from the expression $\frac{X_L^S}{X_H^S} = \frac{q_L\left(kq_H c_H + kq_L \Delta c + \lambda \Delta c\right)}{q_H\left(kq_L c_L + \lambda c_L\right)}$

(A15) $\frac{\partial}{\partial B}\left(\frac{X_L^S}{X_H^S}\right) = -\frac{1}{\left[q_H\left(kq_L c_L + \lambda c_L\right)\right]^2} kq_L q_H^2 c_L c_H \frac{\partial \lambda}{\partial B} > 0$

because $\frac{\partial \lambda}{\partial B} < 0$ from (A14).

Proof of proposition 4

The condition for pooling is

(P) $\lambda\left(q_H c_L - q_L \Delta c\right) \geq kq_L \Delta c$.

From this, the pooling condition is relaxed as k decreases because $\frac{\partial \lambda}{\partial k} < 0$ from (A7). The condition is also relaxed as B decreases as $\frac{\partial \lambda}{\partial B} < 0$ from (A14).

Proof of proposition 5

Consider the bureaucrat's problem where the budget is not binding:

$$\begin{aligned} &Max\ q_L X_L + q_H X_H + k\left(B - q_L t_L - q_H t_H\right) \\ &s.t. \quad (IR_H) \quad t_H = \frac{c_H}{2} X_H{}^2 \\ &\qquad\ \ (IC_L) \quad t_L - \frac{c_L}{2} X_L{}^2 = t_H - \frac{c_L}{2} X_H{}^2 \end{aligned}$$

Using the binding (IR_H) and (IC_L), the outputs can be expressed as $X_H = X_H(t_H)$ and $X_L = X_L(t_L, t_H)$. Then the bureaucrat's problem becomes

$$\underset{t_H, t_L}{Max}\; q_L X_L(t_L, t_H) + q_H X_H(t_H) + k\left(B - q_L t_L - q_H t_H\right)$$

The first-order conditions are

$$\frac{\partial X_L(t_L, t_H)}{\partial t_L} = k$$

$$\frac{q_L}{q_H}\frac{\partial X_L(t_L, t_H)}{\partial t_H} + \frac{\partial X_H(t_H)}{\partial t_H} = k$$

Denoting the solutions to the above conditions as t_L^* and t_H^*, let us now define $\overline{B} \equiv t_L^*$.

Suppose the funding authority decreases the budget from $\overline{B}$ by $|dB| = \varepsilon \to 0_+$. The expected output, $q_L X_L(t_L^*, t_H^*) + q_H X_H(t_H^*)$, changes by

$$q_L\left(\frac{\partial X_L}{\partial t_L}\frac{\partial t_L}{\partial B} + \frac{\partial X_L}{\partial t_H}\frac{\partial t_H}{\partial B}\right)dB + q_H\frac{\partial X_H}{\partial t_H}\frac{\partial t_H}{\partial B}dB$$

$$= q_L\frac{\partial X_L}{\partial t_L}\frac{\partial t_L}{\partial B}dB + q_H\left(\frac{q_L}{q_H}\frac{\partial X_L}{\partial t_H} + \frac{\partial X_H}{\partial t_H}\right)\frac{\partial t_H}{\partial B}dB$$

$$= k\left(q_L\frac{\partial t_L}{\partial B} + q_H\frac{\partial t_H}{\partial B}\right)dB$$

The last equality follows from the above first-order conditions.

Let's evaluate $\frac{\partial t_L}{\partial B}$ and $\frac{\partial t_H}{\partial B}$. From the definition of $\overline{B}$, we know that the budget constraint will become binding if the budget decreases from $\overline{B}$ since the bureaucrat will have to modify her unconstrained contract to satisfy the smaller budget. From the binding budget constraint, we have $t_L = B$, implying that

$$\frac{\partial t_L}{\partial B} = 1$$

From the binding (IC_L), which should hold as an identity at equilibrium with respect to B and k:

$$t_L - \frac{c_L}{2}X_L^{\,2} = t_H - \frac{c_L}{2}X_H^{\,2}$$

$$\Rightarrow t_L = t_H + \frac{c_L}{2}\left(X_L^{\,2} - X_H^{\,2}\right)$$

Taking the derivative of the above expression with respect to B gives

$$\frac{\partial t_L}{\partial B} = \frac{\partial t_H}{\partial B} + c_L\left(X_L\frac{\partial X_L}{\partial B} - X_H\frac{\partial X_H}{\partial B}\right)$$

The fact that $\frac{\partial}{\partial B}\left(\frac{X_L}{X_H}\right) > 0$ implies that $\frac{\partial X_L}{\partial B} > \frac{\partial X_H}{\partial B}$. Then $\left(X_L \frac{\partial X_L}{\partial B} - X_H \frac{\partial X_H}{\partial B}\right) > 0$ as $X_L > X_H$. Therefore $\frac{\partial t_H}{\partial B} < \frac{\partial t_L}{\partial B}$. Finally, the fact that $\frac{\partial X_H}{\partial B} > 0$ implies that $\frac{\partial t_H}{\partial B} > 0$ from the binding (IR_H). Therefore, we have proved that $0 < \frac{\partial t_H}{\partial B} < \frac{\partial t_L}{\partial B} = 1$.

From this, the absolute value of the decrease in the expected output when the budget decreases by $\varepsilon \to 0_+$ is

$$\left(q_L k \frac{\partial t_L}{\partial B} + q_H k \frac{\partial t_H}{\partial B}\right) | dB |$$
$$= k\left(q_L + q_H \frac{\partial t_H}{\partial B}\right) | dB | < \varepsilon$$

That is, when the budget decreases by ε from $\overline{B}$, the expected output decreases but less then ε. Given that the funding authority's payoff is $q_L X_L + q_H X_H - B$ (assuming that the bureaucrat does not return unspent budgets), it implies that the funding authority can improve its payoff by decreasing the budget below $\overline{B}$. ■

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