How a Corrupt Official Can Increase His Budget

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Abstract

A principal aware that an agent will steal will nevertheless fund the agent, because the principal values the output the agent produces. The agent in turn will decide how much to steal on period 1 by anticipating how his behavior in period 1 affects the budget the principal will give him in period 2. Under some conditions, the agent can increase the budget he gets by engaging in greater corruption. A budget constraint imposed for the final period can limit corruption in each period, and induce efficient investment.

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JEL classification: D72, D73, D92, H54, H61

1 Introduction

Governmental projects often suffer from cost overruns. Cantarelli et al. (2010) summarize some of the evidence for transportation projects. The Government Accountability Office found that 77% of highway projects in the United States experienced cost escalation. Another estimate is that the average overrun of infrastructure projects is about 50%. A review of 3,500 projects found that overruns are the norm, generally ranging between 40% and 200%.

A major example of cost overruns, caused in part by corruption and incompetence, appeared in the Big Dig project in Boston, Massachusetts. In 2006 a concrete ceiling panel and debris weighing 24,000 kg fell on a car, killing a passenger. Investigation and repair of the collapse caused a section of the Big Dig project to be closed for almost a full year, causing chronic traffic backups.[1] The project suffered from faulty epoxy, light fixtures dropping, sea water leaks. The cost ballooned from $2.6 billion to nearly $15 billion, and was eight years behind schedule. Cost overruns of more than $1 billion at the Veterans Affairs hospital in Colorado arose in large part because of a design that often sacrificed affordability in the name of aesthetics.[2] The theft of funds can be massive: a study of grants to schools in Uganda finds that the schools, on average, received only 13 percent of the grants. Most schools received nothing, with most of a grant captured by local officials (and politicians).[3] Such behavior often has the characteristic of "throwing good money after bad." Consider the following example from Kenya:

> Kenyans need to be informed now that even today the government is perpetuating further actions of corruption, no doubt related to the need to raise money for elections.
>
> Specifically it has committed Ksh. 840 Million by a contract of February 2007 to overhaul four second-hand junk helicopters which were fraudulently purchased through Anglo Leasing type procedures in 1998. Provision has been made in the current budget

[1] https://www.bostonglobe.com/magazine/2015/12/29/years-later-did-big-dig-deliver/tSb8PIMS4QJUETsMpA7SpI/story.html

[2] http://www.denverpost.com/2016/09/21/aurora-va-officials-warned-repeatedly/

[3] Reinikka and Svensson 2004.

> estimates to pay for overhauling the junk helicopters, thus throwing good money after bad. It would be better to cancel the fraudulent deals and instead buy new, functional equipment transparently...The purchase of faulty equipment on whose rehabilitation and maintenance ever greater sums must be spent provides a cover for continued theft of public resources.[4]

Sometimes, however, corruption or excessive spending reduces spending in future periods, or even cancellation of a program. Following is an example:

> The Sesame Workshop was "dismayed" to find out today that a $20 million U.S. program to beam Elmo and his pals in Pakistan has been halted because of allegations of fraud and abuse. "We had what we believed were credible allegation...Rather than continue to throw good money after bad, we thought it was prudent ⋯to cut off this program and wait for the results of the investigation."[5]

A model of corruption should allow for both types of behavior, explaining when each pattern will appear. Our paper does.

An agent who gets money from a principal may steal some of it. The agent's incentives to steal depend on the consequences. One consequence, studied here, is how theft in one period affects opportunities in later periods. A standard approach has theft in one period reduce opportunities for theft in future periods—the agent may be penalized or apprehended, other people may have learned of the theft and so take greater precautions in the future, or the victims may be poorer from the theft, reducing the amount that can be stolen in the future. But there is another effect. Consider a principal who gives money to an agent, which the agent can use to produce a good the principal values. Theft by the agent reduces, other things equal, production of the good. A principal who highly values the good may then compensate by increasing the resources he gives the agent in future periods, so that at least some minimal level of the good is provided. This

[4] http://humanrightshouse.org/noop/page.php?p=Articles/8146.html&d=1

[5] http://abcnews.go.com/International/sesame-street-dismayed-corruption-charge-pakistan-loss-us/story?id=16497

paper explores such effects. In doing so, we shall show conditions under which the agent can gain from stealing, and conditions under which he cannot. Two effects will be seen as important. First, if small investment in period 1 makes the marginal product of investment in period 2 small, the principal gains little from investing in period 2. Second, if the principal's marginal utility from output is high, then a small investment in period 1 would call for a large investment in period 2 because otherwise output would be low. Depending on the strength of these effects, and on whether the agent will continue in office, the agent may gain or lose from stealing in period 1.

We shall also explore how a principal who commits to the level of spending in future periods can limit the incentives to steal, showing conditions under which a fiscal constraint imposed upon the principal can limit stealing by agents. The credibility of such a commitment can depend on the number of agents, and on whether the fiscal cap is imposed on each agent individually, or instead on aggregate spending.

2 Literature

We consider an agent who can steal more the larger the budget he receives. The argument that government budgets are excessive has a long history, perhaps beginning with Hume's view that government is a Leviathan aiming to enlarge itself. The view was formalized by Niskanen (1971) who supposed that a government agency aims to maximize its budget. Besley and Smart (2007) model political agents, who are unknown to maximize voter welfare or to maximize rents extracted from the government. They find that a fiscal constraint imposed upon the budget size is desirable only when political agents are sufficiently likely to be self-interested. Somewhat related are Alesina and Tabellini (1988) and Tabellini and Alesina (1990) who show that voters may favor budget deficits which constrain future public policy. These papers, however, do not capture, as we do, a dynamic feature of a principal-agent relationship, that is, how an agent distorts his behavior to affect the principal's behavior in the next period. Besfamille and Lockwood (2008) point out an inefficiency of a hard budget constraint, which may give an agent excessive incentives for high effort and may discourage investment by this agent anticipating it. Natvik (2013) analyzes governmental production, which requires both labor and predetermined capital, examining how input complementarity and political turnover make capital a tool for incumbents to affect future policy. These models, however, do not treat corruption. Our analysis also relates to Gersbach and Glazer (2009) who consider the ratchet effect of a worker's action affecting a firm's payment in the future. The more the firm pays in one period, the wealthier is the worker in the following periods, and so the more he must be paid for a given effort. This wealth effect can induce an employer to pay little initially and more later on, while the worker may work harder than the employer prefers. The incentive contracts firms offer may therefore cap the worker's earnings.

Much empirical work finds a negative correlation between corrupt environments and firm productivity (see, for example, Yan and Oum 2014, and Dal Bo and Rossi 2007). Similar effects are found in European airports (Randrianarisoa 2015), where strong evidence shows that corruption reduces airport operating efficiency. A study of a large antipoverty program in Indonesia that distributed subsidized rice to poor households estimated that at least 18% of the rice disappeared due to corruption (Olken 2006). A study of road construction in rural Indonesia suggests that about 24% of the spending was wasted or stolen (Olken 2007). Looking at spending by U.S. states, Liu and Mikesell (2014) claim that increased corruption by public officials increases state spending. We look instead at how expected productivity can affect the opportunities for corruption. Some evidence for such causality is given by Kyriacou, Muinelo-Gallo, and Roca-Sagales (2015), who examine the cross-country connection between the size of the construction sector and the public's perceptions of corruption.

Relatedly, competition among local governments has been viewed as limiting corruption. Montinola and Jackman (2002) examine how political or economic competition affects levels of corruption, finding that corruption is lower in dictatorships than in partially democratized countries; but once past a threshold, democratic practices inhibit corruption. With respect to economic competition, their analysis show that membership of the Oil Producing and Exporting Countries (OPEC) increases corruption. Laffont and N'Guessan (1999) empirically explored the relationship between competitiveness and corruption, measuring competitiveness by the openness of African economies. Their results are ambiguous, indicating that the sign of the relationship depends on the level of corruption. Brennan and Buchanan (1980), followed by Edwards and Keen (1996) and Arikan (2004), see competition as allowing firms or residents to move to localities with low corruption, reducing the incentives of any one local government to be corrupt. Menes (1999, 2003) attributes much of the decline in municipal corruption in the United States to the expansion of the American frontier and development of railroads, which raised the elasticity of the local revenue base available to pay bribes or taxes.[6]

3 Assumptions

3.1 The principal and the agent

The principal delegates production to an agent, giving the agent a budget B_t in period t ($t = 1, 2$). The agent spends some of that budget on investment, K_t, and can spend some of that budget on himself, engaging in corrupt stealing.

Investment in each period is a factor of production, generating output in period 2, which the principal values, according to the technology $Q = F(K_1, K_2)$, with $\frac{\partial F}{\partial K_t} > 0$, $\frac{\partial^2 F}{\partial K_t^2} \leq 0$, $t = 1, 2$, and $\frac{\partial^2 F}{\partial K_1 \partial K_2} \geq 0$, meaning that investment in period 1 can increase the productivity of investment in period 2, and hence, affect the principal's action in this period.

The agent's choice of stealing is binary. He can steal nothing, or he can steal a fraction S ($0 < S < 1$) of the budget in any period. The agent's action is observable and verifiable. Stealing costs the agent $C_S > 0$; the agent's benefit from stealing is $U_A(SB_t)$, with $\lim_{SB_t \to 0} U_A(SB_t) = 0$, $U_A' > 0$, and $U_A'' < 0$. The values of S and C_S are exogenously fixed. The agent gets no utility from

[6] Our summary of Brennan and Buchanan (1980), Edwards and Keen (1996), Arikan (2004), and Menes (1999, 2003) relies on Mookherjee (2015).

the output. In summary the agent's utility in period t is

$$\begin{cases} U_A(SB_t) - C_S, & \text{if the agent steals in period } t; \\ 0, & \text{otherwise.} \end{cases}$$

The principal's utility is

$$U_P(Q) - B_1 - B_2, \tag{1}$$

where $U_P' > 0$ and $U_P'' < 0$. The agent's benefit does not matter to the principal, but the resource stolen by the agent, not spent on production, is a loss for him.

Note that K_1 can be interpreted as investment in capital, and K_2 as spending on operating costs, say labor. All we need is that the same agent gets the budgets in the two periods. If the agent responsible for spending in period 2 differs from the agent responsible for spending in period 1, then the agent in period 1 has no incentive to limit theft in that period. So the principal may prefer to commit to having the agent responsible for spending in both periods.

3.2 Timing

The timing of the game is summarized as follows. In period 1:

1. The principal gives the agent a budget B_1.
2. The agent steals or not from B_1, spending the resources left on investment. The agent obtains a benefit $U_A(SB_1)$ from his theft.
3. The principal observes the agent's action, and the agent incurs a cost C_S if he stole.

In period 2:

1. The principal gives the agent a budget B_2.
2. The agent steals or not from B_2, spending the resources left on investment. Production is carried out. The agent obtains a benefit $U_A(SB_2)$ from his theft.

3. The principal observes the agent's action, and the agent incurs a cost C_S if he stole. The principal's utility is determined.

To determine the behavior of the principal and the agent, we work backwards to solve for the subgame perfect equilibrium, first looking at the actions of the principal and the agent in period 2 for a given investment in period 1. We then examine the behavior of the principal and the agent in period 1, each anticipating behavior in period 2.

First, as a benchmark, we derive the budgets and investments in each period, $((B_1^*, B_2^*), (K_1^*, K_2^*))$ that maximize the principal's utility. We call this combination of the budgets and the investments the first-best solution for the principal. Let this solution be internal. Then for $t = 1, 2$,

$$\begin{aligned} &K_t^* = B_t^*; \\ &\frac{\partial U_P}{\partial Q} \frac{\partial F}{\partial K_t}(K_1^*, K_2^*) = 1. \end{aligned} \tag{2}$$

That is, maximizing the principal's utility, represented by (2), requires no stealing in each period and the equalization of the principal's marginal benefit and marginal cost of giving money to the agent.

4 Optimal budget allocation by principal given agent's behavior

4.1 Choices in period 2

For a given budget in period 2, B_2, the agent steals in period 2 if and only if $U_A(SB_2) \geq C_S$. The principal chooses B_2 that maximizes his utility, given the amount the agent invested in period 1, K_1, and anticipating whether the agent steals. Hereafter B_t^s denotes the budget in period t which induces the agent to steal in period t. Then rationally expecting the agent to steal in period 2 the principal chooses B_t^s to maximize

$$U_P(F(K_1, K_2(B_2^s))) - B_2^s = U_P(F(K_1, (1 - S)B_2^s)) - B_2^s, \tag{3}$$

subject to $U_A(SB_2^s) \geq C_S$. The solution satisfies the condition[7]

$$\frac{\partial U_P}{\partial Q}\frac{\partial F}{\partial K_2}(1-S) \leq 1. \tag{4}$$

Relation (4) implicitly gives the principal's best response to the agent's action in the previous period. For intuition, suppose for the moment that with this solution the constraint for the agent does not bind, so that (4) holds with equality. Then an increase in K_1 has two effects on the principal's utility, and therefore, on his choice of B_2^s:[8]

$$\frac{\partial B_2^s}{\partial K_1} = \frac{\partial B_2^s}{\partial K_2}\frac{\partial K_2}{\partial K_1} = -\frac{1}{1-S}\frac{\frac{\partial U_P}{\partial Q}\frac{\partial^2 F}{\partial K_1 \partial K_2} + \frac{\partial^2 U_P}{\partial Q^2}\frac{\partial F}{\partial K_1}\frac{\partial F}{\partial K_2}}{\frac{\partial U_P}{\partial Q}\frac{\partial^2 F}{\partial K_2^2} + \frac{\partial^2 U_P}{\partial Q^2}\left(\frac{\partial F}{\partial K_2}\right)^2}. \tag{5}$$

First, an increase in K_1 may increase the marginal product of K_2 ($\frac{\partial^2 F}{\partial K_1 \partial K_2} \geq 0$ in the first term on the numerator of (5)). That would induce the principal to increase K_2, and hence B_2^s. Second, because output Q increases with K_1, the marginal utility of output declines ($\frac{\partial^2 U_P}{\partial Q^2} < 0$ in the second term on the numerator of (5)). Thus, in general, an increase in K_1 can induce the principal to either increase or reduce B_2^s, depending on the production function and on the utility function. If the principal is almost risk-neutral $\left(\frac{\partial^2 U_P}{\partial Q^2} \to 0\right)$, then increased theft (i.e., a smaller investment) in period 1 induces the principal to reduce B_2^s. If the investments in the two periods are perfect substitutes $\left(\frac{\partial^2 F}{\partial K_1 \partial K_2} = 0\right)$, increased theft in period 1 induces the principal to increase the budget in period 2.

For illustration, see Figure 1, which displays how the agent's budget in period 2 (B_2^s) decreases with theft in period 1. The curve at the bottom shows output Q when the agent, given B_1, stole in period 1, so that $Q = F((1-S)B_1, (1-S)B_2^s)$ which is tangent to the principal's indifferent curve U_D at point D. The curve showing output Q when the agent did not steal in period 1, $Q = F(B_1, (1-S)B_2^s)$, is located above it and is tangent to the principal's indifferent curve U_E at

[7] The assumptions on $U_P(\cdot)$ and $F(\cdot,\cdot)$ imply that the principal's utility function is strictly concave (see the denominator in (5)).

[8] In (5) $K_2 = (1-S)B_2^s$, so that $\frac{\partial B_2^s}{\partial K_2} = 1/(1-S)$.

point E. Thus the agent gets a smaller budget when he stole in period 1 than when he did not. The opposite outcome is illustrated in Figure 2. The point D lies to the right of point E, meaning that the agent's theft in period 1 has the principal increase the budget in period 2.

Example 1. Consider an extreme case, where K_1 and K_2 are perfect substitutes, or $Q = K_1 + K_2$. Let the principal desire output $\overline{Q}$. That output is obtained if and only if total investment over the two periods is $\overline{Q}$.

Because K_1 and K_2 are perfect substitutes, the budget the principal gives the agent in period 2 declines with the amount the agent invested in period 1. In other words, the principal's choice of the budget in period 2 is a strategic substitute of the agent's choice of investment in period 1. The more is stolen in period 1, the larger the budget the principal must give in period 2 in response to it, namely $B_2^s = \frac{\overline{Q}-K_1}{1-S}$, which decreases with K_1. Thus, anticipating such behavior in period 2, the agent will want to steal in period 1 and in period 2.

Example 2. At the other extreme, let $Q = \min(K_1, fK_2)$, with $f < 1$. Let the marginal benefit of output to the principal be greater than the worst possible marginal cost in period 2 (namely, $1/(f(1-S))$). The principal values increased output, but spending for the agent costs him. This means that the smaller is K_1, the smaller is K_2; that is, the more the agent steals in period 1, the smaller the budget he gets in period 2.

Moreover, if $f < 1$, then the agent prefers to steal in period 2 than in period 1, because $(1-S)B_1 = fK_2 = f(1-S)B_2^s < (1-S)B_2^s$. That is, if the agent steals in period 1 then the budget the principal gives the agent in period 2, $B_2^s = \frac{B_1}{f}$, is greater than B_1.

If instead the agent does not steal in period 1, then the budget the principal gives the agent in period 2, in anticipation of the agent's theft then, satisfies $B_1 = f(1-S)B_2^s$, and hence, $B_2^s = \frac{B_1}{f(1-S)}$, which is greater than the budget the agent would be given after stealing in period 1.

In a similar manner, denote by B_t^n the budget in period t which induces the agent not to steal in that period. Then the principal maximizes

$$U_P(F(K_1, K_2(B_2^n))) - B_2^n = U_P(F(K_1, B_2^n)) - B_2^n, \tag{6}$$

subject to $U_A(SB_2^n) \leq C_S$. The solution for this problem satisfies

$$\frac{\partial U_P}{\partial Q}\frac{\partial F}{\partial K_2} \geq 1. \tag{7}$$

Consequently, given K_1, the principal's optimal choice of B_2 is derived by comparing his indirect utility under B_2^s and under B_2^n. Comparison of (4) and (7) indicates that without the constraint for the agent, the budget size maximizing (6) exceeds that maximizing (3) and brings a higher utility to the principal. However, the incentive constraints for the agent require $B_2^n \leq B_2^s$, so that it is not evident which makes the principal better off.

4.2 Choices in period 1

In period 1 the agent either steals or not. Let $B_2(K_1)$ be the principal's utility-maximizing budget in period 2 given K_1, with $B_2(K_1)$ either $B_2^s(K_1)$ or $B_2^n(K_1)$. If the agent steals in period 1, the agent's utility over the two periods is[9]

$$U_A(SB_1) - C_S + \max\left[U_A(SB_2((1-S)B_1)) - C_S, 0\right]. \tag{8}$$

If he does not steal, his utility over the two periods is

$$\max\left[U_A(SB_2(B_1)) - C_S, 0\right]. \tag{9}$$

Thus, the agent will not steal in period 1 if and only if his utility without theft is at least as great as his utility with theft, which gives

$$\begin{aligned} & U_A(SB_1) - C_S + \max\left[U_A(SB_2((1-S)B_1)) - C_S, 0\right] \\ \leq \; & \max\left[U_A(SB_2(B_1)) - C_S, 0\right]. \end{aligned} \tag{10}$$

[9] If $U_A(SB_2(K_1)) - C_S > 0$, then $B_2(K_1) = B_2^s(K_1)$. If $B_2(K_1) = B_2^n(K_1)$, then $U_A(SB_2(K_1)) - C_S \leq 0$ by contradiction. Even if $U_A(SB_2^s(K_1)) - C_S > 0$, $B_2(K_1) = B_2^n(K_1)$ may hold; then $U_A(SB_2(K_1)) - C_S \leq 0$.

When the principal expects the agent not to steal in period 1, the principal chooses B_1^n to maximize

$$U_P(F(B_1^n, K_2(B_2(B_1^n)))) - B_1^n - B_2(B_1^n), \tag{11}$$

subject to (10), in which B_1 is replaced by B_1^n. If the solution does not make the constraints bind for the agent in period 1 and in period 2, then using the envelope theorem (so that B_2 is unchanged as B_1^n changes), it is implicitly given by

$$\frac{\partial U_P}{\partial Q}\frac{\partial F}{\partial K_1} = 1. \tag{12}$$

The following proposition is derived immediately from (2), (7), and (12).

Proposition 1 *The principal can attain the first-best outcome, by allocating the budgets* (B_1^*, B_2^*), *if and only if*

$$\begin{aligned} &U_A(SB_2^*) - C_S \leq 0; \\ &U_A(SB_1^*) - C_S + \max\left[U_A(SB_2((1-S)B_1^*)) - C_S, 0\right] \leq 0. \end{aligned} \tag{13}$$

For proof, see Appendix A.

Proposition 1 describes when the principal has his preferred outcome in equilibrium. If the investments are sufficiently complementary (so that investment in one period greatly increases the marginal product of investment in the other period), as implied in (5), theft in period 1 will lead to a smaller budget in period 2, so that the conditions in Proposition 1 can apply. Contrary to the assertion in Proposition 1, if $U_A(SB_1^*) \leq C_S$, but if investments in the two periods are strong substitutes and $B_2((1-S)B_1^*) = B_2^s((1-S)B_1^*)$ is sufficiently greater than $B_2(B_1^*) = B_2^n(B_1^*)$ (i.e., stealing in period 1 gives the agent a larger budget in period 2) to induce the agent to steal in period 2, the agent, given B_1^*, steals in period 1. If the principal expects the agent to steal in period 1, the principal's utility is

$$U_P(F((1-S)B_1^s, K_2(B_2((1-S)B_1^s)))) - B_1^s - B_2((1-S)B_1^s). \tag{14}$$

If the constraints for the agent are not binding in each period, then using the envelope theorem shows that the principal's best choice of B_1^s satisfies

$$\frac{\partial U_P}{\partial Q}\frac{\partial F}{\partial K_1}(1-S)=1, \tag{15}$$

suggesting that the principal cannot attain the first-best outcome.

The agent is assumed to benefit from corrupt stealing. Instead, we can suppose that the agent does not benefit directly from theft, but rather wants to maximize the budgets he gets, as in Niskanen's (1971) model of the budget-maximizing bureaucracy. Then subject to slight revision of our model, the results we derived above continue to hold: the agent will steal in period 1 if he can thereby increase his budget in period 2. The model can be interpreted in additional ways. The agent may not steal directly, but instead use the funding he gets for services or projects that fit his preferences more than the principal's. For example, a building may be designed to gain architectural awards rather than to best serve residents, or a local official may want to hire many local workers rather than to construct a highway in the most efficient way.

5 Fiscal constraints on the principal

This section examines whether a fiscal constraint on the principal's spending in either period, or on his total spending, can benefit him and induce the first-best outcome with the allocation in (2), i.e., $((B_1^*, B_2^*), (K_1^*, K_2^*))$. We suppose in this section that the principal can commit to the fiscal constraint. We will discuss the time-consistency of the fiscal constraint later. The following Lemma relates to Proposition 1.

Lemma 1 *Suppose $U_A(SB_1^*) \leq C_S$ and $U_A(SB_2^*) \leq C_S$. Let the principal face the fiscal constraint $B_1 \leq B_1^*$ on the budget in period 1. Then the outcome is inferior to the first-best for the principal if*

$$U_A(SB_1^*) - C_S + \max\left[U_A(SB_2((1-S)B_1^*)) - C_S, 0\right] \geq 0. \tag{16}$$

The first-best solution requires a budget in period 1 of B_1^*, as stated in Proposition 1. However, if (16) holds, the agent, given B_1^*, will then steal in period 1. From (5), when investments are strong substitutes, and hence, $B_2((1-S)B_1^*) = B_2^s((1-S)B_1^*)$ is sufficiently large, then the agent may still steal in period 1, expecting that he will be able to steal much in the future even if $U_A(SB_1^*) \leq C_S$. Then B_2^* is no longer the principal's best response. In contrast, the principal can induce the agent not to steal in period 1 by committing to the fiscal constraint in period 2.

Proposition 2 *Suppose $U_A(SB_1^*) \leq C_S$ and $U_A(SB_2^*) \leq C_S$. Let the principal face the fiscal constraint $B_2 \leq B_2^*$ on the budget in period 2. Then the principal attains the first-best outcome with the allocation $((B_1^*, B_2^*), (K_1^*, K_2^*))$, with the agent never stealing in any period.*

For proof, see Appendix B.

If the principal commits to the fiscal constraint on the total budget which just allows him to attain the first-best outcome, namely, $B_1 + B_2 \leq B_1^* + B_2^*$, the principal achieves the same allocation as with the fiscal constraint only on the budget in period 2: after choosing B_1^*, he is inevitably subject to the fiscal constraint $B_2 \leq B_2^*$.

Corollary 1 *Suppose $U_A(SB_1^*) \leq C_S$ and $U_A(SB_2^*) \leq C_S$. Let the principal face the fiscal constraint $B_1 + B_2 \leq B_1^* + B_2^*$. Then the principal attains the first-best outcome with the allocation $((B_1^*, B_2^*), (K_1^*, K_2^*))$, with the agent not stealing in any period.*

Thus, the fiscal cap which constrains the principal's behavior after observing investment in the first period is crucial.

6 Multiple agents

We can ask how the fiscal constraint works with multiple agents who compete with each other for budgets. Consider two agents. Subscript i represents agent $i = 1, 2$. Let the utility function and the production function be common among agents. The agent's incentive is given analogously to the definition in Section 3. The production function is

$$Q_i = F(K_{1i}, K_{2i}). \tag{17}$$

Let the principal's utility be

$$U_P\left(\sum_i Q_i\right) - \sum_i B_{1i} - \sum_i B_{2i}. \tag{18}$$

Aggregate output is the sum of the output by each agent, and hence,

$$\frac{\partial U_P}{\partial Q_1} = \frac{\partial U_P}{\partial Q_2} > 0, \;\; \frac{\partial^2 U_P}{\partial Q_1 \partial Q_2} = \frac{\partial^2 U_P}{\partial Q_i^2} < 0, \;\; i = 1, 2. \tag{19}$$

The first-best outcome for the principal who faces multiple agents has the allocation $((B_1^*, B_2^*), (K_1^*, K_2^*))$ for $i = 1, 2$, such that for $t = 1, 2$,

$$\begin{aligned} &K_t^* = B_t^*; \\ &\frac{\partial U_P}{\partial Q_i}\frac{\partial F}{\partial K_{ti}}(K_1^*, K_2^*) = 1. \end{aligned} \tag{20}$$

So far we considered the fiscal constraint which sets limits on the principal's spending. The results presented in Section 5 for a single agent also apply to any individual agent among multiple agents, because these results are associated with the fiscal constraint placed on an individual budget.

Then we will examine another way to control the principal. Suppose that in period 2, given (K_{11}, K_{12}), the principal is committed to the total budget $B_{21} + B_{22} = 2B_2^*$ he allocates between the two agents. Will agents then steal? The following proposition states that this fiscal constraint imposed on the principal's total expenditure in the final period effectively controls the agents' behavior in the first period.

Proposition 3 *Let* $\frac{\partial^2 F}{\partial K_{2i}^2} < 0$ *for* $i = 1, 2$. *Suppose* $U_A(SB_1^*) \leq C_S$ *and* $U_A(SB_2^*) \leq C_S$ *for* $i = 1, 2$. *Let the principal commit to spend the total budget* $B_{21} + B_{22} = 2B_2^*$ *for period 2. Then the principal attains the first-best outcome with the allocations* $((B_1^*, B_2^*), (K_1^*, K_2^*))$ *for* $i = 1, 2$, *with no agent stealing in any period.*

For proof, see Appendix C.

The assumption with regard to the strictly decreasing marginal product of investment assures that the optimal budget allocation between agents in period 2 is an internal solution. Competition among agents for budgets in the final period reduces the budget an agent who steals gets in that period, thereby affecting agents' incentives for stealing in the previous period, seeking to steal more later, though K_{1i} and K_{2i} are strong substitutes. Thus we have a conclusion resembling the conclusion with a single agent: a fiscal constraint for the final period is crucial. Moreover, both constraints imposed individually and totally induce equilibrium outcomes which are most preferred by the principal.

7 Time consistency of a fiscal constraint

So far we assumed that the principal can commit not to spend more than a fixed amount. Is this fiscal device time-consistent? When the principal faces only one agent, a fiscal constraint in period 2, $B_2 \leq B_2^*$, would not be time-consistent if given B_1^*, the agent would steal in period 1 without it. Because then, without the fiscal constraint of $B_2 \leq B_2^*$, (16) in Lemma 1 holds. Keeping the assumption that $U_A(SB_2^*) \leq C_S$ in Lemma 1, if $U_A(SB_1^*) < C_S$ and the benefit of stealing from B_1^* is strictly lower than its cost, (16) means that

$$U_A(SB_2((1-S)B_1^*)) - C_S > 0 \geq U_A(SB_2^*) - C_S. \tag{21}$$

Hence, $B_2((1-S)B_1^*) = B_2^s((1-S)B_1^*) > B_2^*$ with $U_A' > 0$. Thus the principal's best choice in period 2, after observing the agent stealing in period 1, and expecting the agent to steal in period 2, is greater than B_2^*. Therefore the principal's commitment to $B_2 \leq B_2^*$ is not time-consistent; he may violate this constraint after observing investment in period 1. The agent, who steals in the current period, anticipating that the principal will violate the fiscal constraint in a following period, may make the fiscal constraint moot. Therefore, when investments are strong substitutes, an additional device for enforcement, which makes the fiscal constraint binding, is necessary.[10]

This conclusion on time inconsistency of the fiscal constraint on an individual budget holds for multiple agents. If, however, the principal is constrained to allocate a fixed amount among agents in the final period, agents' outputs are substitutes, so that the principal can give a larger budget to the agent who spent more on investment, while reducing the budget to an agent who stole. Thus, the fiscal constraint on the aggregate budget for period 2 is time-consistent. Having multiple agents benefits the principal. It makes the fiscal constraint not only efficient but also credible. A separate fiscal cap imposed on spending by each agent may appear rigid, but will not credibly discipline an agent who steals in period 1 and anticipates that the principal would benefit from giving him a large budget in period 2. In contrast, a fiscal cap on aggregate spending in period 2 alone, though it may appear loose, credibly controls agents, .

8 When will corruption be prevalent

Our analysis suggests that it matters whether the same agent will continue in the following period; a principal's ability to switch agents will affect an agent's incentives to steal in period 1. If increased K_1 increases K_2, then an agent who can serve only one term has more incentive to steal than an agent in his first term who can increase his budget in the second term by not stealing in the first term. If increased K_1 reduces K_2 that the same agent would receive, then the opposite holds. So it is not clear whether corruption will increase with an agent's tenure. But the analysis does suggest that corruption will vary, in some direction, with tenure. The empirical evidence is consistent with this view. Ferraz and Finan (2011), in a study of Brazilian mayors, find significantly less corruption in municipalities where mayors can get reelected: in municipalities where mayors are in their first term, the share of stolen resources is, on average, 27 percent lower than in municipalities with second-term

[10] If the agent would not steal in period 1 even with no fiscal constraint, the fiscal constraint $B_2 \leq B_2^*$ would be time-consistent, because without this fiscal constraint $B_2(B_1^*) = B_2^n(B_1^*) = B_2^*$, meaning that the principal's best response after observing the agent not stealing in period 1 does not exceed B_2^*.

mayors (who cannot run for re-election). Similarly, in a study of Italian municipalities, Coviello and Gagliarducci (2010) find that an increase in tenure is associated with worse procurement outcomes.

Some governments have therefore tried to limit corruption by limiting the length of time an official stays in office. For example,

> The Malaysian government has enforced that it will rotate its civil servants every three years, in an attempt to tackle corruption within ministries. Once officers hit a three year mark, they will be evaluated, and transferred to another ministry, a spokesperson from the Prime Minister's Office told GovInsider. "This is certainly not a one-off affair but will be done continuously and will also involve officers managing grants, funds, permits, licences and law enforcement," said Dr Ali Hamsa, Chief Secretary to the Government. "For the first phase, 80 officers holding sensitive posts in finance, development and procurement divisions were transferred effective April 18," he added. The regulation to rotate officers has always been in place, but it was enforced after a finance officer allegedly embezzled some US $24 million (RM100 million) from the Youth and Sports Ministry fund over a period of six years, The Star Online reported.[11]

Our analysis shows, however, that rotation of agents can, under some circumstances, increase corruption: an agent who serves only in period 1 does not care if his theft reduces the budget allocated in future periods.

We would expect corruption to be greatest for projects which must be completed, almost regardless of cost. A good example is construction for the Olympics games—host governments face a fixed deadline, they had publicly committed to building stadiums and sports facilities, and failure leads to widespread negative publicity. Corruption in such construction is notorious. For example, The Guardian reported that

> ...Rio has not been able to avoid the other pathologies of stadium and infrastructure construction: large scale corruption and forced removals. Again, historical comparisons

[11] https://govinsider.asia/inclusive-gov/malaysia-rotates-civil-servants-to-tackle-corruption/

> are kind. Sochi was bedevilled by allegations of corruption...when it comes to using the Olympics as a cover for entirely unrelated but fabulously profitable real estate development Rio is a contender. Considered in all promotional literature to be a central Olympic project, the Porto Marvilha redevelopment of the city's historic dock district is only home to the media village and a small technical-operations centre. Not much, but enough for the programme to acquire the urgency of Olympic projects and a gigantic public-private partnership, in which the city government handed over the planning and governance of the city's largest ever development to a consortium of three private construction companies.[12]

Large-scale corruption also appeared in the Sochi Winter Olympics:

> Whatever happens on the ice and snow of Sochi in the next couple of weeks, one thing is certain: this Winter Olympics is the greatest financial boondoggle in the history of the Games. Back in 2007, Vladimir Putin said that Russia would spend twelve billion dollars on the Games. The actual amount is more than fifty billion. (By comparison, Vancouver's Games, in 2010, cost seven billion dollars.) Exhaustive investigations by the opposition figures Boris Nemtsov, Leonid Martynyuk, and Alexei Navalny reveal dubious cost overruns and outright embezzlement.[13]

The literature review above mentioned corruption in road construction. Our analysis would suggest high corruption in that activity, because it is characterized by a high marginal product of spending if too little was invested earlier—completing a road which has a missing midsection can be highly attractive. That is, the marginal benefit of completing the road is very high, and so the principal will fund construction in period 2 even if corruption was rampant in period 1. That generates an incentive for contractors or agents to steal in period 1. So, not surprisingly, "the link

[12] David Goldblatt, "Rio 2016 buildup part of the chaotic and corrupt tradition of Olympic hosts." *The Guardian*, July 26, 2016.

[13] James Surowiecki, "The Sochi effect." *New Yorker*, February 10, 2014.

between corruption and construction is a problem across the globe. Transparency International has long cited the construction industry as the world's most corrupt, pointing to the prevalence of bribery, bid rigging, and bill padding."[14]

In contrast, maintenance, unlike construction, can often be postponed, or not completed, or done piece meal—repair only a section of the road. We would expect less corruption in that activity.

9 Conclusion

This paper extends analyses of corruption by considering how both a principal and a dishonest agent behave when each realizes that actions taken in one period can affect the opportunities for corruption in a later period. Some of the interesting effects appear when an agent who steals in period 1 thereby increases his opportunities for stealing in period 2. That can make corruption self-perpetuating: much corruption in period 1 allows even greater corruption in the next period. But it can also mean that corruption in period 1 will be small if corruption in period 1 reduces, in a time-consistent way, the budget in period 2. The effect can be ameliorated if the principal commits to giving the agent a small budget in period 2, thereby offering one explanation for the efficiency of fiscal caps. Our analysis also shows that competition among multiple agents makes commitment binding, thereby reducing corruption.

Much work on corruption examines how culture, political institutions, education, incomes, and so on affect corruption. But surprisingly little work examines, as we do, the dynamics of corruption, how theft in one period affects theft in future periods. And little work has examined how corruption will vary with the type of activity, say why corruption is especially prevalent in construction. Our analysis offers a start.

[14] James Surowiecki, "The Sochi effect." *New Yorker*, February 10, 2014.

Appendix A: Proof of Proposition 1

If $U_A(SB_2^*) - C_S \leq 0$, given $K_1 = B_1^*$, the principal's optimal choice in period 2 is $B_2(B_1^*) = B_2^n(B_1^*) = B_2^*$. Therefore,

$$\max[U_A(SB_2(B_1^*)) - C_S, 0] = \max[U_A(SB_2^*) - C_S, 0] = 0. \tag{A.1}$$

If $U_A(SB_1^*) - C_S + \max[U_A(SB_2((1-S)B_1^*)) - C_S, 0] \leq 0 = \max[U_A(SB_2(B_1^*)) - C_S, 0]$, the principal, anticipating that the agent does not steal in period 1, can optimally set $B_1 = B_1^n = B_1^*$. Thus there exists an equilibrium in which the principal allocates (B_1^*, B_2^*) and the agent never steals. This equilibrium is unique because the principal's utility is at the maximum. Thus Proposition 1 is proven.

Appendix B: Proof of Proposition 2

The first-best solution for the principal requires him to set (B_1^*, B_2^*), and to induce the agent to spend all the budget on investment.

In period 2, given B_2, the agent steals if and only if $U_A(SB_2) \geq C_S$. Then given any K_1, under the fiscal constraint $B_2 \leq B_2^*$, and under the assumption that $U_A(SB_2^*) \leq C_S$, the principal's optimal choice of the budget for period 2 induces the agent not to steal in that period, because the principal's utility-maximizing choice of the budget in period 2, $B_2(K_1)$, is subject to the fiscal constraint, and therefore, the following should hold:

$$U_A(SB_2(K_1)) - C_S \leq U_A(SB_2^*) - C_S \leq 0. \tag{B.1}$$

Therefore, given K_1, the principal's best choice of the budget in period 2, without theft by the agent in that period, is $B_2(K_1) = \min[B_2^n(K_1), B_2^*]$.

In period 1, the principal chooses an internal solution $B_1^n = B_1^*$, because given that $U_A(SB_1^*) \leq C_S$, and noting that $U_A(SB_2((1-S)B_1^*)) - C_S = U_A(S\min[B_2^n((1-S)B_1^*), B_2^*]) - C_S \leq 0$, the agent, given B_1^*, does not steal in period 1. Then $B_2(B_1^*) = \min[B_2^n(B_1^*), B_2^*] = B_2^*$. Thus, there exists a unique equilibrium in which the principal sets the budgets (B_1^*, B_2^*), inducing the agent not to steal in each period. Thus Proposition 2 holds.

Appendix C: Proof of Proposition 3

We will show that under the fiscal constraint $B_{21} + B_{22} = 2B_2^*$, there exists an equilibrium in which the principal gives each agent (B_1^*, B_2^*) and the agent spends all the budget on investment.

In period 2, given B_{2i}, agent i $(i = 1, 2)$ does not steal if and only if $U_A(SB_{2i}) \le C_S$.

Anticipating the agent's reaction, given K_{1i} and K_{1j} $(j \ne i, j = 1, 2)$, the principal allocates the budget in period 2 between the two agents, to maximize

$$U_P(F(K_{1i}, K_{2i}(B_{2i})) + F(K_{1j}, K_{2j}(B_{2j}))), \tag{C.1}$$

subject to

$$B_{2i} + B_{2j} = 2B_2^*. \tag{C.2}$$

The necessary condition for the principal's optimal allocation is

$$\frac{\partial U_P}{\partial Q_i}\frac{\partial F}{\partial K_{2i}}(1 - S_i) = \frac{\partial U_P}{\partial Q_j}\frac{\partial F}{\partial K_{2j}}(1 - S_j), \tag{C.3}$$

where $S_i = S$ when the principal expects agent i to steal (then $(K_{2i}(B_{2i}) = (1 - S)B_{2i})$; $S_i = 0$ when he is expected not to steal (then $(K_{2i}(B_{2i}) = B_{2i})$. In a similar manner S_j is defined. The values of S_i and S_j have to be consistent with the agents' behavior in period 2. This equation indicates that the marginal products are equalized between agents.

For the moment suppose that S_i can take any value within the interval $[0, 1)$. Then

$$\begin{aligned}
\frac{\partial B_{2i}}{\partial S_i} &= \frac{\partial B_{2i}}{\partial K_{2i}}\frac{\partial K_{2i}}{\partial S_i} \\
= \quad & -\frac{1}{1 - S_i}\frac{-\frac{\partial U_P}{\partial Q_i}\frac{\partial F}{\partial K_{2i}}}{(1 - S_i)\left[\frac{\partial^2 U_P}{\partial Q_i^2}\left(\frac{\partial F}{\partial K_{2i}}\right)^2 + \frac{\partial U_P}{\partial Q_i}\frac{\partial^2 F}{\partial K_{2i}^2}\right] - (1 - S_j)\frac{\partial^2 U_P}{\partial Q_i \partial Q_j}\frac{\partial F}{\partial K_{2i}}\frac{\partial F}{\partial K_{2j}}} \\
= \quad & \frac{1}{(1 - S_i)^2}\frac{\frac{\partial F}{\partial K_{2i}}}{\frac{\partial^2 F}{\partial K_{2i}^2}} < 0,
\end{aligned} \tag{C.4}$$

where we used (19) and

$$\frac{\partial F}{\partial K_{2i}}(1-S_i)=\frac{\partial F}{\partial K_{2j}}(1-S_j), \tag{C.5}$$

which is also derived from (19) and (C.3). We can interpret this result as showing that fixing agent j's behavior, the budget the principal wants to give agent i when the agent is expected to steal a fraction S of the budget in period 2 ($S_i = S$), which we call $\tilde{B}^s_{2i}$, is smaller than the budget he prefers to give the agent i when the agent is expected to steal nothing ($S_i = 0$), which we call $\tilde{B}^n_{2i}$.

In period 1, given B_1, agent i can choose whether to steal or not. From (C.3) agent i calculates

$$\begin{aligned}
&\frac{\partial B_{2i}}{\partial K_{1i}}=\frac{\partial B_{2i}}{\partial K_{2i}}\frac{\partial K_{2i}}{\partial K_{1i}}\\
=\quad&-\frac{1}{1-S_i}\frac{(1-S_i)\left[\frac{\partial^2 U_P}{\partial Q_i^2}\frac{\partial F}{\partial K_{1i}}\frac{\partial F}{\partial K_{2i}}+\frac{\partial U_P}{\partial Q_i}\frac{\partial^2 F}{\partial K_{1i}\partial K_{2i}}\right]-(1-S_j)\frac{\partial^2 U_P}{\partial Q_i \partial Q_j}\frac{\partial F}{\partial K_{1i}}\frac{\partial F}{\partial K_{2j}}}{(1-S_i)\left[\frac{\partial^2 U_P}{\partial Q_i^2}\left(\frac{\partial F}{\partial K_{2i}}\right)^2+\frac{\partial U_P}{\partial Q_i}\frac{\partial^2 F}{\partial K_{2i}^2}\right]-(1-S_j)\frac{\partial^2 U_P}{\partial Q_i \partial Q_j}\frac{\partial F}{\partial K_{2i}}\frac{\partial F}{\partial K_{2j}}}\\
=\quad&-\frac{1}{1-S_i}\frac{\frac{\partial^2 F}{\partial K_{1i}\partial K_{2i}}}{\frac{\partial^2 F}{\partial K_{2i}^2}}\geq 0.
\end{aligned} \tag{C.6}$$

Thus, when agent i steals in period 1, he anticipates that the principal may reduce his budget in period 2, because the marginal product of investment in period 2 is affected by investment in period 1.

In period 1, the principal wants to give each agent B_1^*, because under the assumption that $U_A(SB_1^*) \leq C_S$, given B_1^*, agent i does not steal in period 1:

$$\begin{aligned}
&U_A(SB_1^*)-C_S+\max\left[U_A(SB_{2i}((1-S)B_1^*,K_{1j}))-C_S,0\right]\\
\leq\quad&\max\left[U_A(SB_{2i}(B_1^*,K_{1j}))-C_S,0\right],
\end{aligned} \tag{C.7}$$

where we use

$$\max\left[U_A(SB_{2i}(B_1^*,K_{1j}))-C_S,0\right]\geq\max\left[U_A(SB_{2i}((1-S)B_1^*,K_{1j}))-C_S,0\right], \tag{C.8}$$

because from (C.4) and (C.6):

(i) If $0 \geq U_A(S\tilde{B}^n_{2i}(B_1^*,K_{1j}))-C_S > U_A(S\tilde{B}^s_{2i}(B_1^*,K_{1j}))-C_S$, the principal's expectation that

$S_i = 0$ is consistent with agent i's actual behavior. Then $U_A(S\tilde{B}_{2i}^n(B_1^*, K_{1j})) - C_S \geq U_A(S\tilde{B}_{2i}^n((1-S)B_1^*, K_{1j})) - C_S > U_A(S\tilde{B}_{2i}^s((1-S)B_1^*, K_{1j})) - C_S$, so that agent i would not steal after stealing in period 1. Thus (C.8) holds.

(ii) If $U_A(S\tilde{B}_{2i}^n(B_1^*, K_{1j})) - C_S > U_A(S\tilde{B}_{2i}^s(B_1^*, K_{1j})) - C_S \geq 0$, the principal's expectation that $S_i = S$ is consistent with agent i's actual behavior. Then whether $B_{2i}((1-S)B_1^*, K_{1j}) = \tilde{B}_{2i}^n((1-S)B_1^*, K_{1j})$ or $B_{2i}((1-S)B_1^*, K_{1j}) = \tilde{B}_{2i}^s((1-S)B_1^*, K_{1j})$, (C.8) holds.

Then in period 2, the principal gives each agent the optimal budget $\tilde{B}_2^n(B_1^*, B_1^*) = B_2^*$ under the fiscal constraint $B_{21} + B_{22} = 2B_2^*$, expecting no agent to steal. Indeed, $U_A(SB_2^*) \leq C_S$ by assumption, so that this expectation is consistent with the agents' behavior. Thus, there exists a unique equilibrium in which the principal can set the budgets (B_1^*, B_2^*) for agents 1 and 2, inducing the agents not to steal in each period. Thus Proposition 3 holds.

Notation

B_t Budget principal allocates in period t

B_t^* Budget principal allocates in period t in first-best solution for principal

B_t^n Budget principal allocates in period t when he anticipates agent will not steal in that period

B_t^s Budget principal allocates in period t when he anticipates agent will steal in that period

C_S Cost to agent of stealing

$F(K_1, K_2)$ Production function

K_t Investment in period t

K_t^* Investment in period t in first-best solution for principal

Q Output

S Fraction of budget that can be stolen

U_A Utility of agent

U_P Utility of principal

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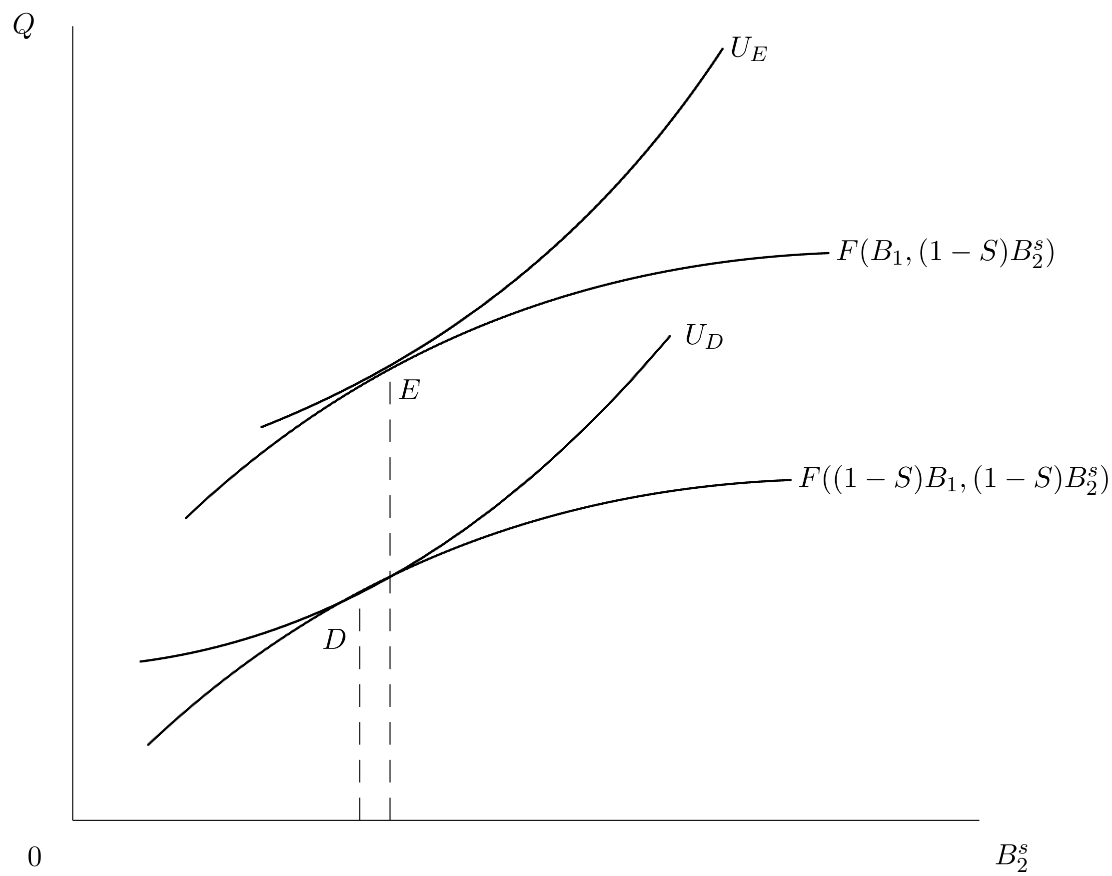

Figure 1: Theft in period 1 reduces the budget in period 2

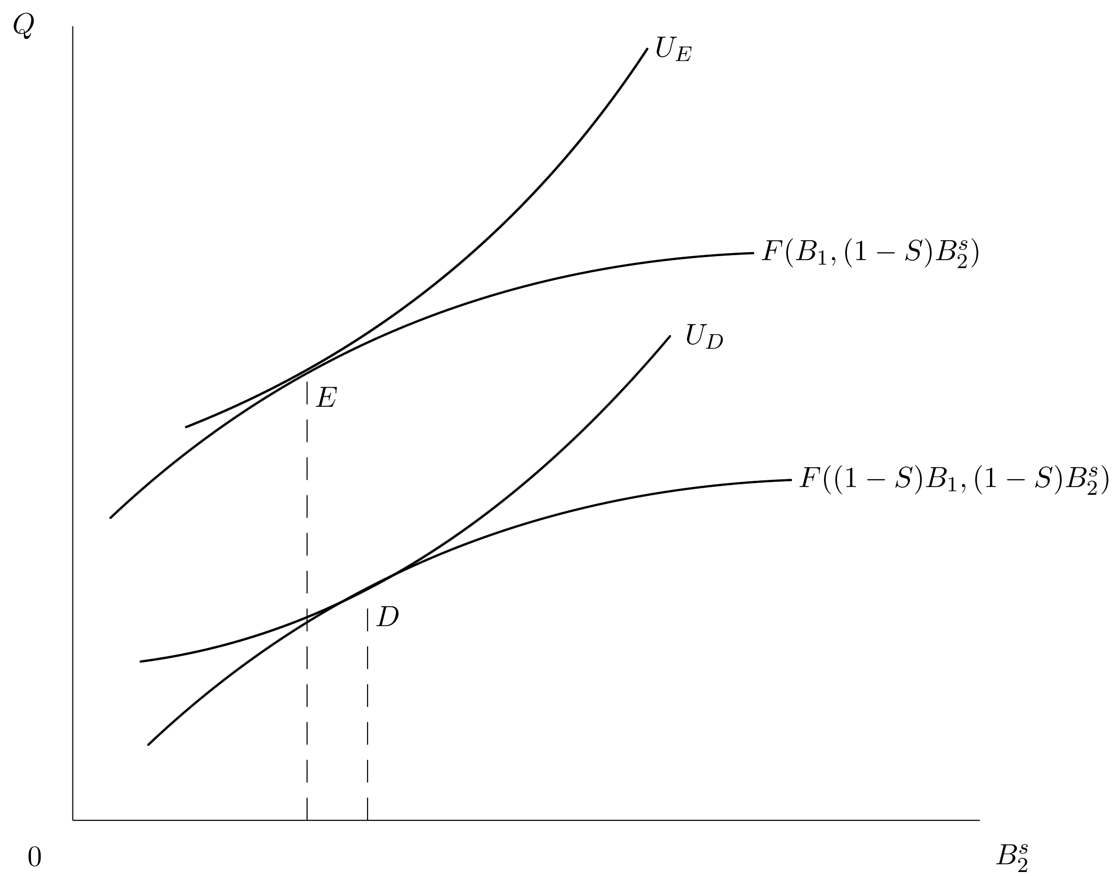

Figure 2: Theft in period 1 increases the budget in period 2