From: *The Natural Resources Trap: Private Investment without Public Commitment,* William Hogan and Federico Sturzenegger (eds.), Cambridge, MA: MIT Press, 2010, 197-226.

6 Denying the Temptation to GRAB

Nils Wernerfelt and Richard Zeckhauser

6.1 Introduction

On March 18, 1938, Mexican President Lázaro Cárdenas expropriated the oil facilities of all foreign investors in Mexico. As in most cases of expropriation, the justification was shady, and it involved the combined efforts of several branches of the Mexican government. In light of the government's coup, every March 18 Mexico celebrates the "Expropiación Petrolera" (the "Oil Expropriation"). While having a national holiday celebrating expropriation does not send a positive message to foreign investors, the story of Mexico in 1938 has been repeated countless times in countries throughout the world, and continues to thrive in modern times.[1] And this cautionary tale does not just apply to the oil industry. All forms of natural resources are at risk, ranging from coal mines to beachside resorts. Indeed, though our focus is on natural resources, any concentration of fixed assets, such as a steel plant or even a bank, is subject to confiscation. In the developing world, where expropriation problems are most severe, few resource-laden countries have a strong enough rule of law to make investors confident. Only a few more have a history of protection sufficient that their reputation alone offers protection.

If the rule of law or reputations were strong enough to ensure contracts would be honored, then the situation would be very different. The government could sell development rights at the outset, or impose lump-sum taxes on resource deposits, and thereby avoid distorting the firm's incentives to go about its activities efficiently, to the benefit of the country. Alternatively, the government could simply tax a constant fraction of company earnings, taking proper account of capital costs. Either way, the government could prevent most future bad experiences abroad by overseas investors. Unfortunately, given real-world contractual insecurities, for many nations such secure sale or tax arrangements will remain theoretical niceties.

Foreign investment in natural resources is both expensive and widespread, and often requires significant private-sector skills.[2] It is disturbing that there are very few cases where private firms and developing-country governments work in harmony, thus enabling firms to pursue efficiency and confidently plan for the long run. Expropriation risks produce a portfolio of problems. The firm may not merely slacken its efforts; it may change its whole investment strategy.

This chapter is part of the general literature on insecure property rights and their consequences for economic efficiency. (See, for example, Shleifer and Vishny 1994; Che and Qian 1998.) The literature points out that there are other modes of expropriation or partial expropriation beyond merely taking over the firm. Sharp rises in taxation play this role; so do regulations that say labor must be paid far above its competitive wage.

In this literature, the tools of modern contract theory have opened the door for analyses of contracts that are optimal given unavoidable expropriation risk should certain conditions arise (Bohn and Deacon 2000; Engel and Fischer 2008; Schwartz and Trolle 2010; Mahajan 1990). A prime factor promoting expropriation is higher net returns to the government if the asset is in its hands. In some instances counter-threats may prevent expropriation. Thus, the country whose firm has been expropriated can retaliate by blocking assets or imposing trade sanctions or other forms of international pressure.[3] However, if such measures fail to deter, and the ongoing stream of expropriations suggest that they often do, the firm whose property has been taken will be a severe loser. As a consequence, any firm with a big asset at stake will anticipate, and seek to reduce, the factors that would lead to expropriation. Usually, such firm actions will hurt the host country.

Similarly, such firm actions may affect other countries as well, and the benefits or costs to the uninvolved countries might depend on a number of factors, including firm size. A larger firm, for example, might be able to afford to place refineries and other secondary processing plants in safer countries, whereas a new firm might not have that luxury. This would benefit the country that receives these plants at the cost of harming the alternative host country. To illustrate how a negative effect might be experienced by an outside country, assume that a South American country expropriated a mining property. Then firms might be less likely to invest in South America in general, thereby

harming the entire continent. This reputational externality would ideally be controlled by groups of resource-rich countries trying to constrain their members' tendencies to expropriate.

As with any agency problem, agency losses will be shared. Hence both the principal (the government) and the agent (the firm) have an interest in reducing such losses, at least before any contracts are drawn or investments are undertaken. In theory, for example, the firm bids at the outset to develop a resource. Bids will be lower if expropriation is a risk, implying the government as well as the firm will gain if the temptation to expropriate can be partially or completely denied.

Assuming the occasional expropriation is unavoidable, the literature has focused on contracts designed to implement a given investment. Engel and Fischer (2010) prove the insightful result that a contracted cap on a firm's profits, equivalent to a super windfall tax, can act as a safeguard against expropriation in high states of profit.[4] The existing literature has mostly focused on moral hazard on the magnitude of the investment. Following earlier work, Engel and Fischer posit that firms bid competitively for the contract by announcing the lowest cap they would accept. If the firm's choice is only how much to invest, this approach secures maximal monies for the government, and also has the lowest-cost firm develop the resource.

Our analysis builds on this work by introducing a number of responses that the firm and then the government might take to dampen expropriation risk. In particular, we look at firms' willingness to severely sacrifice expected return to avoid projects yielding the types of high payoffs that might lead to confiscation. In this vein, firms may also inefficiently smooth profits over time. We also address situations where two or more phenomena interact. When the problems just mentioned intrude, preferred contracts may diverge substantially from the second-best optimal contracts for cases where the straightforward problem is mere discouragement of investment.

We first outline the potential factors that influence the government's decision to expropriate the resource. We label these relationships the GRAB function, where *GRAB* has its normal meaning: "get hold of or seize quickly and easily."[5] It is also an acronym for Gain and Retain Another's Belongings—in other words, to expropriate. Then, taking this GRAB function to be exogenous, as we do throughout, we examine what effect its hovering presence will have on the firm and its investment decisions. Specifically, we consider how firms select lotteries over profits, and then examine how moral hazard and adverse selection complicate matters. Then we examine how the government can address the aforementioned issues. The government basically has two approaches. It can induce the firm to take more favorable actions despite expropriation risk, or it can find measures that tamp down its own temptation to GRAB. Finally, we look at some policies the firm can undertake to improve the situation, basically by making a GRAB less likely.

We should note at the outset that our analysis is stylized. It often invokes simplified models to facilitate intuition and understanding. At times we play put and take with assumptions, thus dealing with one phenomenon at a time. Some of our results are merely presented as figures, in geometric terms. Given our simplifications, some of the measures we identify to reduce temptation would be difficult or impossible to implement politically. However, their structure often points in appropriate directions.

The rest of the chapter is organized as follows. Section 6.2 discusses the nature of the government's commitment problem and the nature of the GRAB function. Section 6.3 discusses how the firm distorts its investments when a GRAB threatens. Section 6.4 details how the government might induce firms to invest more and more appropriately when they confront the threat of a GRAB. Section 6.5 discusses the challenge of hidden information. Section 6.6 describes mechanisms available to the government and then the firm to reduce the temptation to GRAB. Section 6.7 concludes the chapter.

6.2 The GRAB Function

Expropriation is almost always a probabilistic threat as opposed to a certainty over the relevant range of investor decisions. Otherwise, the investor or firm—the two terms are used interchangeably here—would not create the conditions for expropriation, since payment in case of expropriation rarely comes close to making the firm whole.[6] As is common in the literature, we posit that the probability of expropriation rises with the magnitude of profits the investor is securing. That is because the government's benefits from expropriation rise with profits, but its accompanying costs likely rise less rapidly, as we explain below.

The government's decision to expropriate may not result from a straight financial cost-benefit calculation; it may also be subject to populist pressures that we would expect to rise with the magnitude of the investor's profits. In this light, populist pressures could arise from nationalist desires to have full control over the country's resources—for example, the belief that these resources should belong to the people, not to some multinational firm. More pragmatically, they could be stirred by desires for increased funds for the government to allocate within the country, or for better treatment of its workers.

Cognizant of the power of populism, however, populist pressures may also be stirred by those in power with the ultimate goal of rationalizing expropriation. Others may stir them to enhance their chance of securing power, and the corrupt may push them as a means to get more resources under their control, thereby increasing their private wealth.

As a first step in developing a model for expropriation, call the investor's profits, Π, the amount the government would get if it could run the operation as effectively as the firm and with no other consequences. Π is computed on a discounted expected value basis. Additional costs to the government, should it take over the operation, fall into three categories: efficiency costs, reputation costs, and payment costs. The efficiency costs are incurred because the government cannot produce as efficiently as the investor. Reputation costs, namely a reduced ability to get other firms to invest in the future, increase with the magnitude of profits, but far less than proportionally. A $200 million expropriation sends more shivers to the investor community than does a $100 million expropriation but hardly twice as many. Payment costs rise with Π because even expropriating governments usually pay something absolutely and at the margin, albeit invariably far less than fair market value. These categories of cost will come onstage occasionally below, but for the most part we just assume that they are positive and substantial.

Beyond these benefits and costs, a third factor influences the expropriation decision, namely the potential populist benefits from expropriating. These too are put into a financial equivalent term to simplify exposition.[7] Putting all of these elements together produces the function $f(\Pi)$, which gives the probability of expropriation, where it should be reemphasized that Π is what the firm loses, not what the government reaps. We expect $f'(\Pi) \geq 0$—that is, a greater pot of resources creates a greater likelihood of a GRAB. Though $f(\Pi)$ can equal 1 for high values of Π, the investor would be unlikely to choose such a Π, since, as mentioned, payment is likely to be woefully insufficient. However, such Π values may occur by chance after a prudent investment decision, say if mine exploration discovers a mammoth deposit.[8] One reason why f(Π) is probabilistic is that many of these costs and benefits are quantities that are hard to assess. Moreover, they are subjectively judged by the government, the potential seizer of assets.

The government certainly will not show its hand in advance—for example, by saying what level of profit will make expropriation likely. We take f(Π) to be subjectively assessed by the firm. In a more elaborate game-theoretic analysis, we could think of the government as determining f(Π) as part of a game, where it would trade off the need to get firms to build up the value of their assets against the benefits it receives when expropriations do and do not take place.[9]

From the standpoint of investors, the relevant GRAB function is the one they believe. That makes it the relevant function for the government as well, at least to the extent that it is worried about investor behavior. In the parlance of game theory, the GRAB function in the eyes of an investor should be common knowledge. The investor is trying to guess how the government will behave. And both parties are attempting to assess a range of factors from future profits to efficiency losses given expropriation, from uncertainties about benefits and costs to evolving populist pressures. In short, the two players are engaged in a highly conjectural game about the behavior of the other, of what nature will do, and of third-party sentiment.

The elaborate game that emerges is summarized in the f(Π) function. For example, when investor decisions are being made, we can expect the government to provide reassuring words, attempting to lower the perception of the f(Π) function. These words may be something more than what economists call "cheap talk," namely mere platitudes with no consequence. Such words in some sense are quasi promises. Schelling (1960, 117) observes that a player's public proclamations that she will return the favor assuming another party does something beneficial for her puts her reputation on the line and changes her payoffs. They make it worthwhile for her to carry out the promise. Quasi promises surely change payoffs, but both parties understand that they may not do so sufficiently when the temptation to renege (in this case to expropriate) gets sufficiently great. Reassuring words about expropriation that are spoken softly may provide only modest reassurance (i.e., only slightly lower f(Π)), but when provided effectively and widely disseminated the shift will be greater, since breaking a widely broadcast commitment will discourage other potential investors.

The consequence of an f(Π) whose value is not simply 0 is that investor decisions can be distorted in many ways. The most discussed, to be sure, is the simple discouragement of investment. Engel and Fischer provide an insightful treatment of the discouragement problem in chapter 5. We consider a range of important complementary distortions.

6.3 When GRABs Threaten, Moral Hazard

Whenever an arrangement provides for a transfer from A to B depending on the outcome, and when A has some control over the outcome, moral hazard intrudes. A will no longer take the actions he would in the absence of the contract. In our context, the arrangement is the f(Π) function, A is the firm, and B is the government. Given f(Π), the firm will no longer make the efficient investment, since B will be grabbing some of his profits. Such a deviation is called moral hazard.

The investor's expected loss from expropriation is f(Π)Π. In a scenario where there is neither a GRAB function nor risk aversion, the investor simply maximizes E(Π). Take the simplest case where there is no investment decision to be made, and there is no uncertainty about profits. The investor can just select profits from a range. Maintaining the assumption of risk neutrality but introducing a GRAB function, the investor now maximizes E(Π(1 – f(Π))). Since f(Π) ranges from 0 to 1, we can see that the expectation will be lower here. As long as f(Π) is increasing over the relevant range, the expected profits from a higher Π will be countered with a smaller 1 – f(Π) term. Thus, the firm will simply select a lower profit level than it would absent a potential GRAB.

If we drop the risk-neutral assumption and assume risk aversion, we are then maximizing E[U(Π)] in the situation where there is no GRAB function, and E[U(Π(1 – f(Π)))] when there is a GRAB function. Note that since the utility function is concave, risk aversion further reduces these values compared to their corresponding values in the risk-neutral setting. The potential for a GRAB reinforces any mean-reducing propensity of risk aversion. This should be understood in what follows, where for simplicity we assume risk neutrality.

6.3.1 Discouraged Development: Certain Profits

Let us return to the case where firms have to invest up front to produce profits, and can invest at variable levels. If there is the prospect of

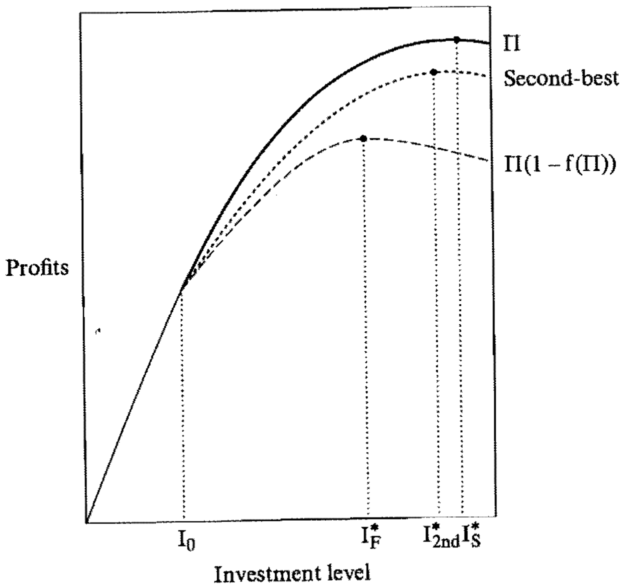

Figure 6.1
The certainty case

losing their investment—particularly if as we both assume and expect, likelihood increases with the magnitude of future profitability—investment will be discouraged. Sometimes they will not invest at all. In others, they will simply invest less than they otherwise would. The first case we treat has profits expressed as a certain function of the magnitude of investment (see figure 6.1). In this figure, three curves are shown. The solid curve shows profits if expropriation is ruled out. The dashed curve shows the expected return to the firm, $\Pi(1 - f(\Pi))$. The point I_0 shows where $f(\Pi)$ begins to be positive. The social optimum, assuming no possible GRAB, is at I_S^*. The firm's optimum is at I_F^*.

If the government expropriates, we will assume that it receives profits $b\Pi$, where $0 < b < 1$. The dotted curve indicates the expected returns to the government and firm together given the presence of $f(\Pi)$. Thus, the dotted curve takes into account the sacrifice in efficiency because the government will sometimes operate the resource. The formula for the dotted curve is

$$\Pi(1 - f(\Pi)) + b\Pi f(\Pi) = \Pi(1 - (1 - b)f(\Pi)).$$

The second-best optimum is at I_{2nd}^*. We assume $f'(\Pi) \geq 0$ when $f(\Pi > 0)$. The three curves and the three optimality points will have the relationship shown, where the optimal investment for the firm will be below the optimal second-best investment given the $f(\Pi)$ function, which in turn will be less than the optimal social investment assuming that the government would never GRAB. In short, the firm will underinvest.

This analysis leaves aside three other benefits that the government secures from the investment: (1) It may sell the concession at the outset. (2) It may impose ordinary taxes and possibly some severance taxes on the firm. (3) The operation of the firm yields benefits to the citizens of the country, and presumably the government counts these as a benefit. In each case, these extra considerations make it worse for the government to have its potential GRAB reduce the firm's investment. We will not discuss these extra considerations further below, though in virtually all cases they reinforce the desirability of each of our recommended policy measures. In short, even when profits are certain, the government would welcome temptation-inhibiting measures, which if put in place would enhance the firm's profitability and its investment.

6.3.2 Distribution Distortion: Uncertain Profits

For most real-world cases, there will be substantial uncertainty in the profit level. Most models of moral hazard simply assume that investors determine how much to invest. However, the investor may also be able to influence the distribution of returns. For example, in exploring for oil in a particular field, one has a choice of drilling strategies. Strategy S may be the "safe" strategy, offering a higher probability of a smaller find than strategy R, the "risky" strategy, which has a higher expectation but more variable returns.

In a potential expropriation situation, more variable returns are not welcome, since they increase the expected cost of expropriation holding mean returns and mean expropriation probability fixed. To see this, consider two equally likely levels of profits, $\Pi_1 < \Pi_2$, with respective expropriation probabilities $f(\Pi_1) < f(\Pi_2)$. The expected GRAB will be $[\Pi_1 f(\Pi_1) + \Pi_2 f(\Pi_2)]/2$. By contrast, if there were a certain profit level equal to $\Pi_c = [\Pi_1 + \Pi_2]/2$, with $f(\Pi_c) = [f(\Pi_1) + f(\Pi_2)]/2$, the expected GRAB would be less by $0.25[\Pi_2 - \Pi_1][f(\Pi_2) - f(\Pi_1)]$. Note that this quantity is strictly positive, because each term is positive. In effect, an expected GRAB is a rectangle, where the width is the profit level and the height is the probability of expropriation. With variable

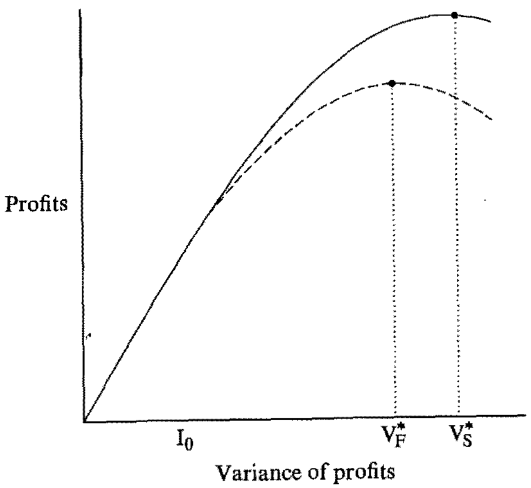

Figure 6.2
Uncertainty case; investment of I

returns, a weighted average of the areas of these rectangles is computed, where the weights are the likelihoods of each profit level, to get a total expected GRAB. Holding the expected probability of a GRAB and the expected cost of a GRAB fixed, the more variable profits become, the more bigger widths are multiplied by bigger heights, resulting in a larger total expected GRAB.

To simplify in the uncertain profits case, we will assume that the firm is risk neutral, and only one level of investment is possible. The firm invests I at step 1, probabilistic profits Π are realized at step 2, and whether there is a GRAB is determined at step 3. The firm is able to make more or less risky investments and thus selects the distribution from which Π is drawn. Since the government is more likely to GRAB when Π is high, the firm will have an incentive to invest in ways that are too conservative—that is, in ways that sacrifice mean profits so as to reduce variance.[10] Figure 6.2 illustrates this point. The solid curve shows profits as a function of variance, assuming no GRAB. The dashed curve subtracts the expected GRAB from the solid curve. The firm will optimize at V_F^*, whereas the social optimum assuming no GRAB is at V_S^*. The firm will invest too little.[11]

The term *distribution distortion* refers to situations where such disproportionate sharing—in this case between the government and

the agent—causes an agent to depart from what would be his optimal action. This phenomenon is very general, and influences the behavior of executives with stock options, investors with confiscation threats, and asset owners who have insurance. In each of these cases, the outside party—respectively shareholders, the government, and the insurance company—have a nonlinear claim on returns. The term distribution distortion was developed for insurance contexts (Zeckhauser 1996), where someone with insurance may accept a small risk of a larger loss to avoid a larger risk of a small loss despite this leading to a larger expected loss, since the larger loss gets a greater percentage compensation from the insurance. Here the expected returns to the outside party are quite the reverse and lead to excess risk avoidance, not excess risk taking.[12]

6.3.3 Delayed Development

The investor has to be concerned that Π becomes sufficiently large that the government will find it worthwhile to expropriate. Posit an extreme case where only the investor has the ability to discover and exploit a mine, though the government can expropriate the resource once discovered and developed. In this extreme case, the investor will then find it worthwhile to constrain the discovery and development process to deter a GRAB. The most likely way this would be done would be to dribble investment over time, even though the firm would invest much more rapidly if the assets developed were secure.

Suppose, for example, that the firm can extract the entire profit X in a single period but also can spread it over several periods. If there are substantial fixed costs of operation per period, or if current prices—as with oil in June 2008—are above expected future prices, or merely because money is worth more today than tomorrow, the former is most efficient. However, if f(X) is much greater than f(X/2), the firm will extract over two periods and thus sacrifice efficiency. An asset subject to expropriation is like a store in a high-crime neighborhood; it is imprudent to have too much inventory on hand.

6.4 Government Measures to Promote Appropriate Investment

The government suffers when firms respond in the ways described in the previous section. First, the government will probably sell concessions, say to develop resources, at the outset. If profitability will be lower, firms will pay less. Second, the government may collect ordinary taxes on a firm's profits and the economic activity it generates. Third, the government, representing its citizens, will care about payments to other entities. Fourth, given that it will sometimes expropriate, the government has a self-interest in a higher profit level. In this section we discuss incentives the government can provide to induce firms to invest more and more appropriately. We assume that if the government does end up expropriating, such incentives are not paid. That is, expropriation is total.

We next analyze the government's ability to optimally constrain its propensities to GRAB in the context of models that successively incorporate different considerations. The models assume that the parties can contract on profits (e.g., on a tax or royalty program, or indeed on payments that go from the government to the firm) that would pertain in the absence of expropriation. We realize that some such contracting may be difficult in practice—for example, the government may not want to incur the wrath of the populace by negotiating contracts that hand over large payments to a foreign firm.

6.4.1 The Optimal Constrained Payment Schedule When I^* Is Observable

Consider first the simplest conceivable situation in which only one type of investment is possible, though the investment amount can vary and the amount invested, I, can be inferred or observed. Given everything, the government has an ideal investment level, I^*, for the firm. There is no problem if the firm will reach this level when optimizing for itself. Assume that it will invest too little. The simplest solution is for the government to compensate the firm enough that it covers the cost up to I^* if and only if it is undertaken. If any payment were politically acceptable, and if payments did not affect the likelihood of a GRAB, the government would merely pay an amount P if $I \leq I^*$, where P was just sufficient to make the investment worthwhile for the firm.

Given that profits are uncertain, this arrangement would entail paying the firm in cases where profits are very low and also when they were very high. The former would be politically unpalatable; the latter would surely promote a GRAB. A more feasible solution might thus be to have the payment depend on profits. Specifically, if profits are Π, and there is no GRAB, then the firm could get $P = p(\Pi)$ along with Π, if and only if the desired investment is undertaken. But what would $p(\Pi)$ look like? The distribution of profits assuming that I^* is invested is $g(\Pi \mid I^*)$. The firm will get paid by the government an amount $p(\Pi)$, a payment that is employed to get the firm to invest more than it otherwise would, but an amount that can sometimes be negative. Thus, assuming no GRAB, the firm receives $\Pi + p(\Pi)$. With a GRAB it gets nothing. The firm and the government have a common interest in avoiding extremely high profits for the firm, lest there be a GRAB, which creates a deadweight loss. Presumably the government is selling a concession at the outset, or otherwise extracting a significant portion of the firm's return, say through a royalty payment. Hence, it wishes to minimize the deadweight loss. As Engel and Fischer show, looking at the case where only the firm pays the government, the optimal program, taking account of $f(\Pi)$, caps the firm's profits. Hence, the firm pays the government when big profits are realized—that is, at the top. The government has a constraint at the bottom as well. For political reasons, it cannot pay the firm for investing when little has been produced in terms of profits. The firm's maximum payment function, is indicated as $MAX(\Pi)$. (Note that this formulation prevents the government from paying some or all investment costs up front.) Finally, the sum of $p(\Pi) + \Pi$ cannot be decreasing with Π, since the firm can always throw away some profits. Figure 6.3 shows the optimal constrained payment schedule from the standpoint of the government. It is indicated as the heavy curve. To compute the expected payoff going to the firm, the values on the curve would be integrated over $g(\Pi \mid I^*)$.

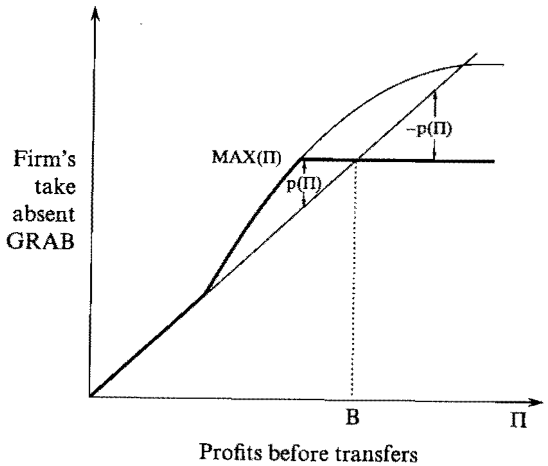

Figure 6.3
The optimal constrained payment schedule

As before, the firm's profits, including its payment from the government, might be GRABbed.

One critical constraint is that the firm must be securing enough expected payment from the government to cover its investment cost. That is why the structure cannot simply cap profits. Given investment I^*, the firm's expected payoff is

$$\int p(\Pi)g(\Pi \mid I^*)(1 - f(\Pi))\,d\Pi + \int \Pi g(\Pi \mid I^*)(1 - f(\Pi))\,d\Pi,$$

where the first term is the expected net transfer from the government and the second term is its own expected profits. This sum must be at least equal to I^*.[13]

6.4.2 The Optimal Constrained Schedule When I* and Investment Type Are Observable

Things are more challenging if the firm can choose not merely the magnitude of the investment, but its type, as indicated say by its variance, V. We capture the nature of the investment by the distribution of returns it will produce. Concern for distribution distortion was covered in section 6.3. Fortunately, and not surprisingly, if both the amount and nature of investment are contractible, a first-best outcome is achievable, assuming the government can just make a payment when it gets the result it wishes. Basically, the government just solves the problem of what pair I^*, V^* yields the social optimum. It then "pins" this outcome by offering to pay the amount $Q = q(I^*, V^*)$ if $I \leq I^*$ and $V = V^*$, thereby giving the firm the minimum incentive that gets it to invest the socially optimum amount. The solution to the case will be just like the case where the government pays P if $I < I^*$.

In fact, of course, this solution is likely no more feasible in practice than was the simple payment of P. The government is constrained in what it can pay, and it also must be concerned with $f(\Pi)$. Given that, it will simply replicate the solution outlined in figure 6.3. It will base payments on profits, will provide for $MAX(\Pi)$ over a range, and then will cap the total returns to the firm.

6.4.3 Optimal Payments When the Investment Type Cannot Be Observed

We now move on to the more realistic situation in which the firm and government cannot contract over the choice of investments. As before, we posit that $f(\Pi)$ is exogenously given. Rarely will the first best be

achievable. Hence, we often must settle for second best. Throughout this section, to keep things as simple as possible, we assume that the amount of investment, I, is exogenously given at I^*.[14] Because the parties cannot contract on the type of investment, they will write a contract promising the firm a payment $P = p(\Pi)$, since Π is the only thing that can be observed.

This sets the stage for a very interesting conflict. The government wants to reward the firm for high values of Π in order to implement risky investments, but the firm wants to avoid such realizations in order to prevent expropriation. But it should be recognized that the firm and government, despite disparate interests, are really partners. They both wish to find the $p(\Pi)$ function that yields a second-best outcome, given the $f(\Pi)$ function and the investment possibility curve. The optimal $p(\Pi)$ function may depend on the relative benefits being accorded to the firm and the government. The anchor points of the Pareto frontier are the respective levels of welfare if the government does nothing, and the firm simply optimizes against $f(\Pi)$. But there is a range of outcomes where both parties do better. If the government can choose $p(\Pi)$, obviously it will pick the function that is best for itself, subject to the constraint that the firm will participate (i.e., not be a loser).

6.4.3.1 Example Involving Two Technologies Whether or not the government can provide appropriate incentives will depend on the distribution of profits and the nature of the GRAB function. We illustrate with an extreme example, with only two possible technologies. Technology 1 gives profits Π_1 for sure, while technology 2 gives profits Π_2/μ with probability μ and 0 with probability $1 - \mu$, where $\Pi_1 < \Pi_2$. So technology 2 is more efficient, and its choice would be the government's goal. If the GRAB function $f(\Pi)$ is such that $f(\Pi_1) = 0$ while $f(\Pi_2/\mu) > 1 - \Pi_1/\Pi_2$, no $p(\Pi)$ can implement technology 2. Thus, technology 1 will be chosen.

With other parameter values, incentives can implement the preferred outcome. Let $\Pi_1 = 1$, $\Pi_2 = 1.5$, and $\mu = 0.5$. Thus, if the firm selects technology 2, there is a 0.5 chance of a payoff of 3. If $f(3) = 0.5$, the expected profit to the firm is $3(0.5)(0.5) + p(3)/2$, or $0.75 + p(3)/2$. Thus, for $p(3) > 0.5$, the firm will choose technology 2.

6.4.3.2 Continuous Choice of Technologies Let us return to an earlier example where the firm has a continuous choice reflecting a trade-off between mean and variance. The government receives considerable benefit from the firm's profits—including possibly selling the concession at the outset—for a variety of reasons. Thus, it promises the firm an additional payment p(Π) to induce it to invest for a higher mean. Otherwise, the firm will simply choose too compressed an earnings distribution. We begin with five assumptions:

1. The maximum government payment to the firm is capped due to populist pressures.
2. The maximum government payment is small relative to the firm's expected loss from expropriation.
3. Given that the government is seeking to have the firm produce more profits, it is politically unacceptable to pay the firm more when profits are low than when profits are high.
4. When profits are high, the higher they are the more likely it is that the firm in fact chose a high variance–high mean investment. (This is the monotone likelihood assumption.)
5. The government's payment, p(Π), is treated as equivalent to Π. Thus, the argument of the GRAB function is $f(\Pi + p(\Pi))$.

If there were no potential for a GRAB, the government would simply pay the firm a big amount when revenues were high. For any given expected payment by the government, this turns out to be the instrument that gets the firm to push for the highest mean return. Essentially, the government is making its payoff as high as possible when it is most likely that the firm has done what it wishes. We know from extensive work on monotone likelihood models, that high payoffs in the tail provide the most incentive bang for the buck. This payment is indicated as "ideal" in figure 6.4.

The cap on the government payment, of course, prevents an extremely high (and politically infeasible) payment way out in the tail. Thus, the nature of the optimal contract, absent the GRAB threat, might give the firm $50 million (the maximum feasible prize) if profits reach or exceed $300 million.[15] This payment is indicated as "capped" in figure 6.4.[16]

Alas, a GRAB is a threat, and any payments through p(Π) help to promote a GRAB. Thus, the government must attend to this when choosing the p(Π) function. We address this situation, but leave aside the cap and MAX(Π), which would complicate the analysis. Three important factors come into play: (1) The firm's payoff, $\Pi + p(\Pi)$, cannot

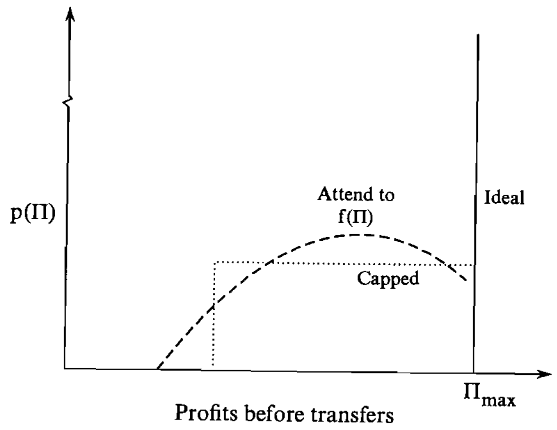

Figure 6.4
Optimal payment schedules

be decreasing, lest it capitalize on free disposal. (2) The goal should be to have p(Π) high when Π is high in order to counteract the firm's tendency to compress the revenue distribution as it seeks to avoid a GRAB. (3) A countervailing consideration to (2) is to hold down p(Π) when Π is high to reduce the probability of a GRAB, for the GRAB threat also leads the firm to avoid high outcomes.

Putting these three factors together, we know first that the p(Π) function cannot focus payments in the lower tail as a means to promote a high variance. Second, it will be designed to reduce the likelihood of a GRAB. The optimal function will be optimal at every point. Thus, in looking at the GRAB propensity at two points, one relevant consideration for increasing p(Π) at either will be $f'(p(\Pi) + \Pi)$ at those two points, namely the cost that comes from increasing the GRAB likelihood. To illustrate, we will assume that over the relevant range $f'' > 0$, there are increasing marginal costs in terms of GRAB likelihood.[17] This factor will be a force for having p(Π) decline with Π. But we also know that the monotone likelihood consideration will make it desirable to have p(Π) be highest for larger values, producing a tension. The dashed curve in figure 6.4—indicated as "Attend to f(Π)"—shows one possible resolution of these forces. Its initial rise phase reflects the desirability of putting density on higher values. Ultimately it begins to decline in response to the ever-increasing marginal effect of p(Π) on the GRAB likelihood.

6.5 Hidden Information

Kenneth Arrow (1985) proposed the phrase "hidden information" to describe situations where one party has knowledge the other does not. The term more commonly applied to such situations is "adverse selection." But that term is inferior for our circumstances, since it is usually applied in insurance contexts, and since it implies a particular type of action, namely choosing whether to insure (and at what value). Our ultimate concern here is whether the firm should invest, and if so how much and in what way. Our intermediate concern is how the government can structure contracts to produce the best possible outcome given the information situation. The amount of investment I may be unobservable. If so, it will be subject to moral hazard. But that does not mean that the situation is hopeless.

6.5.1 The Expected Externalities Solution: Two-Sided Asymmetric Information

Fortunately, the government has some tools at its disposal to extract private information. Thus, for example, it can extract information by asking the firm to declare its type, and making future payments contingent on its declaration. The declaration will also guide the government in choosing what temptation-control measures to put in place. A transfer payment (sometimes negative) will go from the government to the firm depending on the firm's declaration and the government's response to it. The nexus of this mechanism is to have the parties pay one another the expected cost each imposes on the other due to its choice, whether that declaration is about information or an action. This approach is called paying the expected externality (Pratt and Zeckhauser 1987).

The government, not merely the firm, may have hidden information. If so, two-sided problems of asymmetric information may arise. This situation can be modeled in simple and stylized form by assuming that a firm already has a concession, and that two resource development projects are possible, Little and Big. The Little project will do no environmental damage. But the Big project will afflict the environment, producing damages of D, which the government values fully. The firm knows its potential profits. Using this information, and any incentives to which it is subject, it chooses the project to be undertaken to maximize its profits net of incentives. The direct profits from the Little project will be 2; the direct profits for the Big project are known to the firm,

but not the government. The damages, D, which are fully valued by the government, are known only to the government. It is common knowledge that the Big project profits are uniform on [2, 4], and that damages are uniform on [0, 1]. There is no chance the Little project will be expropriated. If the Big project is built, it is 20 percent likely to be GRABbed. If it is GRABbed, the government gets an incremental benefit of 0.5Π. Thus, the government's expected profit if the Big project is built is $(0.2)(0.5)\Pi = 0.1\Pi$.

The payoffs going forward are as follows:

	Little project	Big project
Firm	2	0.8Π
Government	0	$0.1\Pi - D$

The social optimum, subject to the constraint that the GRAB probability cannot be altered, is for the government to signal D honestly, and for the firm to invest in Big if $.8\Pi + .1\Pi - D > 2$. Thus, the formula for the social optimum is

$$\frac{1}{2}\int_0^1 \int_{(D+2)/.9}^4 .9\Pi - D d\Pi\, dD + \frac{1}{2}\int_0^1 \int_2^{(2+D)/.9} 2\, d\Pi\, dD = 2.359$$

The firm contributes 2.414 of this value, meaning the government receives $-.055$, assuming no side payments.

We will compute three outcomes with three mechanisms: no externality payment, the one-way externality payment, and the two-way externality payment. We will compare the results they achieve to this social optimum. The analysis follows the traditional economic approach of charging parties for the externalities they impose, with two extensions that comprise the foundation of the expected externalities mechanism. First, parties are charged for their declarations as well as their actions. Second, where information is not public, charges are made on an expected value basis using common priors.

6.5.1.1 No Externality Payment Suppose first that the firm must determine which project to undertake with no further knowledge of environmental damages. If $0.8\Pi > 2$, it will build the Big project, namely if $\Pi > 2.5$. The firm's payments will be given by $(0.25)(2) + 0.5\int_{2.5}^4 (.8\Pi)\, d\Pi = 2.45$, and the government's by $0.5\int_{2.5}^4 .1\Pi\, d\Pi - 0.75\int_0^1 D\, d\Pi = -.13125$. Thus, the total social surplus is $-.13125 + 2.45 = 2.319$.

6.5.1.2 One-Way Expected Externality Payment by Firm The traditional economic approach will charge the firm for the expected environmental damage it imposes on the government, which is 0.5. Given this, the firm will build the Big project when $0.8\Pi > 2.5$, namely when $\Pi > 3.125$.

Appropriate accounting for externalities will recognize that the government also benefits when it GRABs. Thus, the government must pay the firm the net expected externality it receives when the firm builds Big. This payment could in theory be negative or positive, since it has both a negative (environmental externality) and positive (GRAB potential) element. That expected externality is $0.1\Pi_B - D$, where Π_B is the expected value of Π when it is worthwhile for the firm to build Big. The firm will find the value Π^* such that $0.8\Pi^* + 0.1E(\Pi \mid \Pi > \Pi^*) - 0.5 = 2$ or $0.85\Pi^* = 2.3$. That value is $\Pi^* = 2.706$. Then $\Pi_B = 3.353$. The expected externality that the firm conveys to the government when it builds the Big project is thus $0.1(3.353) - D$. On average, D will equal 0.5. Therefore, the expected externality that the firm conveys to the government when it builds the Big project is $0.335 - 0.5 = -0.165$. Paying this amount to the firm when it builds the Big project produces the optimal outcome absent communication. The firm will build Big if $0.8\Pi - 0.165 = 2$, or if $\Pi > 2.706$, which appropriately is the Π^* found above. The expected payoffs to the two players will thus be $0.5 \int_2^{2.706} 2\, d\Pi + 0.5 \int_{2.706}^4 .8\Pi - 0.5 + 0.1\left(\frac{4+2.706}{2}\right) d\Pi = 2.335$ for the firm, and $0.5 \int_0^1 \int_{2.706}^4 D - .1\left(\frac{4+2.706}{2}\right) + .1\Pi - D\, d\Pi\, dD = 0$ for the government. Total social surplus is thus simply 2.335.

6.5.1.3 Two-Way Expected Externality Payments and Communication The two-way expected externality approach takes advantage of communication. The government first announces D^*, and then pays the firm the expected externality. That payment is equal to the change in the firm's expected profit from some base case. We take the base case to be that D^* is announced as 0. It is important to note that the announcement creates two different externalities to the firm. First, the announcement may induce the firm to build Little rather than Big; the greater D^* is, the more likely this is to happen. Second, D^* affects the subsequent externality payment the firm will pay to the government if it does build Big. Both of these effects would be taken into account in computing the expected externality that the government pays for making its declaration. After it hears the announcement and receives the payment from the government, the firm decides to build Big or Little. Its choice will take into account its own profits plus what it must pay the government for its decision. The firm then pays the government for its Big or Little decision. Little is taken to be the base case.

Thus the firm pays 0 if it chooses Little. The profit-maximizing firm will build Big for any value of $\Pi \geq \Pi^*(D^*)$. At this marginal (cutoff) value Π^*, the firm conveys an externality to the government of $0.1\Pi^* - D$ should it build Big. Thus, efficiency is served if the firm pays the government the amount $D^* - 0.1\Pi^*$ when it does build Big, assuming that the firm maximizes its profits after payment. It will build Big, as appropriate, if and only if $\Pi \geq \Pi^*$.

Obviously, this two-way externality format can be streamlined by subtracting the second payment (firm to government) from the first (government to firm), and computing the net payment by the government to the firm for the announcement of D^* given the choice of Big or Little.

The value of $\Pi^*(D^*)$ is given by $.8\Pi^* - D^* + .1\left(\frac{2+D^*}{.9}\right) = 2$. Thus, the cutoff value is $\Pi^*(D^*) = \frac{20}{9} + \frac{10}{9}D^*$. In light of this second-stage action, the government at stage 1 will select D^* to maximize its payoff. Specifically, it can compute the change in the firm's profits from announcing $D = 0$ versus $D = D^*$, the amount it will have to pay to the firm. This comes out to be $-\frac{20}{81}(D^*)^2 + \frac{64}{81}(D^*)$. Being subject to this expected externality, the government, maximizing its expected return, calculates

$$\max_{D^*} -\frac{20}{81}(D^*)^2 + \frac{64}{81}(D^*) + \frac{1}{2}\left(4 - \frac{2+D^*}{.9}\right)$$

$$\times \left(D^* - .1\Pi^* - D + .1\left(\frac{1}{2}\right)\left(4 + \frac{2+D^*}{.9}\right)\right)$$

Note that this quantity is equal to the initial lost payment to the firm plus the probability of the firm's building Big times the firm's payment to the government minus the environmental damage, and plus the expected value to the government of a potential GRAB. Solving this for $D(D^*)$, we see that the government sets $D^* = D$. Thus, the government correctly reports the environmental damage from building Big. Furthermore, from this equation, we can see that the formula for Π^* is the same as it is in the social optimum. Thus, we know we must be able to implement the first best.

The total expected payoffs are

$$\int_0^1 \left(\frac{1}{2}\int_2^{(20/9+10/9D)} 2\, d\Pi + \frac{1}{2}\int_{(20/9+10/9D)}^4 - D + .9\Pi\, d\Pi\right) dD = 2.359\ldots$$

Similarly, the government's payoff is

$$\int_0^1 \left(\frac{20}{81} D^2 - \frac{64}{81} D + \frac{1}{2} \int_{20/9+10/9D}^{4} .1\Pi - \frac{2}{9} - \frac{D}{9} d\Pi \right) dD = -.273\ldots$$

A similar expression for the firm yields profits to it of roughly 2.632.

We now compute the efficiency performance for the various schemes. We take the social optimum (constrained to recognize the GRAB function) to be 100 percent, and the outcome in the absence of any externality payment to be 0. The expected payoffs are

Payments	Firm	Government	Total payment	Efficiency
None	2.450	−0.131	2.319	0
One-way EE	2.335	0	2.335	39.986%
Two-way EE	2.632	−0.273	2.359	100%
Social optimum	2.414	−0.055	2.359	100%

The relevant efficiency indicator is given by the fourth column. The distribution of payoffs between the government and the firm in the table should be given little weight, since they could be shifted from the firm to the government without any loss through an up-front concession charge, or by changing the base cases from which externality payments are computed. Similarly, if multiple firms bid for the concession, excess profits to the winning firm will be competed away. The critical finding is that one-way expected externality payments are far below the social optimum, and that two-way externality payments can achieve the social optimum despite the information asymmetry.[18]

6.5.2 Moral Hazard, Distribution Distortion, and Hidden Information

Our analysis thus far has addressed government self-control mechanisms that work well when one or two of the key problems of moral hazard, distribution distortion, and hidden information are part of the picture. However, often all three are present. Consider a situation where a firm has hidden information about the state of the world. Using a variation of the example from section 6.3.2, suppose that there are two possible states. Thus, the firm knows whether a project is reasonably safe or quite risky. In state 1, the project gives profits Π_1 for sure if and only if an investment of I_1 is made, where $I_1 \geq I_a$ and $I_a < \Pi_1$. In state 2, it gives profits Π_2/μ with probability μ and 0 with probability $1-\mu$ if and only if an investment I_2 is made, where $I_2 \geq I_b$ and $I_b < \Pi_2$. We assume that $\Pi_2/\mu > \Pi_1$ and that $\Pi_2/\mu - I_b > \Pi_1 - I_a > 0$. This implies that for either state the projects are profitable, but the project yields greater expected value in state 2.

Unfortunately, GRABbing is also more likely in state 2. Assume now that the GRAB function $f(\Pi)$ is deterministic, namely that $f(\Pi) = 0$ for $0 < \Pi \leq S$, and $f(\Pi) = 1$ for $\Pi > S$, where $I_a < S < \Pi_1$ and $S < I_b$. In this case, the government can implement investment in state 1 by simply doing nothing. But there is nothing the government can do to implement investment in state 2 because positive profits in that state, along with any payment from the government, are sure to generate a GRAB.

Under some circumstances the government can solve this problem by paying some of the firm's investment costs up front. This significantly tilts the firm toward being a contractor rather than an independent entrepreneur. For example, the firm might be given a choice to simply proceed on its own or to take a contract under which it is paid J up front and T if $\Pi > 0$. The firm will accept this contract in state 2 if $\mu T - I_b + J > 0$. It will simply proceed on its own in state 1 if profits going alone are greater, namely if $\Pi_1 - I_a > T + J$.

6.6 Temptation-Reducing Mechanisms

6.6.1 Government's Mechanisms

The government has several other tools at its disposal beyond those analyzed above. For example, to make the firm less fearful about expropriation, to lower the $f(\Pi)$ curve, it can voluntarily choose to implement a future hand-tying mechanism against expropriation.[19] Schelling-type promises would have this effect, since they would put the credibility of the government on the line, or the international reputation of its leader, and lower the government's payoff should an expropriation be undertaken.

A promise may not have long-term credibility if governments turn over, particularly between parties with different ideologies. This suggests that competitive democracies may have more trouble reassuring investors than governments that tend to stay in power over long periods. Fortunately, the current government may have some tools that can even tie up future governments of a quite different complexion. For example, the country could allow, indeed encourage, the firm to put in place machinery for which the country could not get spare parts.

The limiting case would make the efficiency loss total. That would entirely remove the temptation to GRAB.

Alternatively, the government could post a bond, presumably with some impartial overseas organization. Of course, it would be prohibitively costly to post a separate bond for each investment in a nation. Presumably, the bond would cover a broad panoply of investments within the country. The government would end up a loser if it expropriated one or two properties. This assumes that the government cannot confiscate everything at once. Thus, it might have ten different firms in different areas, with a mean profit of $1,000 in each area, but it might only have to put up $3,000 to ensure reasonable security. Part of the security comes because not all assets are susceptible to GRABs at the same time. This situation bears parallels to an insurance arrangement, where not everything bad happens at once. The bond would be paid off by a third party, presumably some independent agency overseas, to the extent that the government violated the contract. The contract might even give the government the right to GRAB above some point, which might be necessary with populist sentiment, even if it would mean forfeiting something on the bond. The bond method could be extended to effective GRABs, such as measures that dramatically raise taxes, force the employment of local workers, set excessively high wages, and so on. It would only be essential that such developments or effects be spelled out in the contract, or be subject to the determination of the third-party agency. Note that the agency is not acting as an insurer, only as an adjudicator and payment agent. Ideally, such an adjudicator would build up a reputation for fairness over time, and would deal with many nations, playing somewhat the role that a court does in commercial disputes in the United States.

Governments, of course, have other measures that may represent partial confiscations and that can provide feedback to affect firm behavior. Among tools in the category of tax policy, it is important to note the distinction between taxing price and taxing quantity. A windfall tax on "excess price" merely promotes moral hazard, say lowered investment; a windfall tax on "excess production," however, promotes both moral hazard and distribution distortion. Moral hazard can be fought through governmental contribution to the investment, by insuring price on the downside, or if a binding forward contract is possible with the market, the firm can hedge its price. Price is readily observable. Production, and particularly optimal production, may be less observable. Thus, in an optimal arrangement, the firm will keep a greater

share of "excess profits" that come from unexpected production than from unexpected price.

6.6.2 Firm's Mechanisms

6.6.2.1 Extra Payments Thus far we have looked at the problem mostly from the standpoint of the government trying to get the firm to behave in an efficient fashion, even though the government itself cannot commit to refrain from efficiency-damaging expropriation. But the firm may seize the initiative and seek to make it worthwhile for the government not to expropriate. It can do this by agreeing to give the government greater profits than it otherwise would receive in the dangerous circumstances when the profits are great.[20] Posit that the $f(\Pi)$ function is immutable, where Π gives the profits the firm will reap. For simplicity, let us posit also that all investments and investment decisions have been made, and the firm is just waiting for probabilistic profits to be realized. Despite having no obligation, the firm may find it desirable to grant the government some profits for any value of Π so as to discourage a GRAB. Let $q(\Pi)$ be the positive profits granted to the government if Π eventuates.[21] The relevant GRAB function then becomes $f(\Pi - q(\Pi))$. Note that from the government's standpoint, this is equivalent to magnifying the inefficiencies it suffers if it conducts the firm's business. Thus, if the country only operates oil wells half as efficiently as the firm, that imposes a cost of 0.5Π on the government and makes a GRAB less likely. The firm cannot pick the government's efficiency level, but it can enhance the benefits to the government should it refrain from a GRAB. Here the firm picks $q(\Pi)$ to maximize its own expected profits:

$$q^*(\Pi) = \arg\max_{\Pi}[\Pi - q(\Pi)][1 - f(\Pi - q(\Pi))]$$

For example, if $0 < \Pi < 1$ and $f(\Pi) = \Pi$, then $q^*(\Pi) = \Pi - 0.5$ if $\Pi > 0.5$, and otherwise $q^*(\Pi) = 0$, since the payment to the government cannot be negative. This solution is general for any $f(\Pi)$ function. The firm in effect plots its expected after-GRAB profits as a function of actual profits, leaving aside $q(\Pi)$. Over any interval where that function dips, it pays the government an amount that places it at the bottom of the interval—that is, at the prior peak. Note that the $q(\Pi)$ function is independent of the distribution of profits.

This maximization can be envisioned as follows. The firm can draw its expected profits curve. Over any interval where it expects its after-GRAB take to diminish, it can continue across the dip on a horizontal line, thereby making the function monotonically increasing. The difference between the horizontal lines and Π will be paid out to the government. For example, consider the following scenario: $\Pi \in [0, 10]$, with $f(\Pi) = 0$ for $\Pi \leq 6$ and for $\log(\Pi - .5)/2$ for $\Pi > 6$. Here, the expected payoffs dip around 7, which can be smoothed over by a horizontal $q(\Pi)$ function.

6.6.2.2 Extralegal Solutions Firms subject to holdup may reduce the likelihood of a GRAB by influencing the behavior of leaders. This can be done in one of two ways: (1) making it less likely that an expropriation-prone leader is chosen, or (2) affecting the behavior of whichever leader is in office. Experience from Peru, Venezuela, and so on illustrates such actions by firms. It is important to note that such activity, albeit having strong distasteful elements, could actually be in the country's interest.

Another counterintuitive way the country could benefit is through the use of certain types of bribes. The GRAB function may depend not merely on profits but also on the leader's actions. A firm's ex ante anticipation that it will bribe a leader not to GRAB can benefit the country. To be sure, the expected cost of the bribe will come out of what the firm will pay for a concession; this produces a loss in profit for the country, a direct cost. But if a leader can switch the outcome from GRAB to not GRAB in a sufficiently broad range of circumstances, the resources saved may more than offset the profit loss from the bribe. The critical question, of course, is how large the bribe has to be to get the leader to change. Note that the outcome with optimal bribes is not equivalent to having the ruler(s) of the country merely own the resource, as they do in many oil-rich nations. Then they will still have the incentive to expropriate. The critical element of a bribe is that party A pays party B to give away party C's property. In our context, party C (the citizens of the country) cannot prevent this from happening.

6.7 Conclusion

Firms will respond in a self-interested manner to a government's temptation to GRAB their assets. The literature has analyzed the general inhibition of investment, but GRAB threats will induce firms to change their types of investments as well—for example, by compressing the distribution of payoffs at the expense of the mean. Fortunately, the forward-looking firm or government has tools available that can influence the future division of any profits, and thereby boost the expected payouts to both the firm and the country. If confiscations threaten, favorable outcomes will be served if effective controls are put in place before temptation looms.

Notes

The authors would like to thank Bijan Mossavar-Rahmani for his insightful ideas and remarks, and Laurence Tai for his able research assistance.

1. For example, on April 30, 2008, Venezuelan President Hugo Chávez expropriated a foreign steelmaking plant.

2. Though our discussion throughout is of a foreign firm as the investor, it applies equally well to domestic firms, which also do get expropriated.

3. There is even a premise with precedent called extraterritoriality, which allows country A to interfere in country B's companies that operate in country C, if country A is sufficiently opposed to the company's functioning there.

4. We should note that this chapter grew out of the authors' discussion of Engel and Fischer's piece at the 2007 Harvard conference. Their effort was so stimulating that we asked if we could write a paper inspired by it.

5. From wordnet.princeton.edu/perl/webwn.

6. For example, in the aforementioned case from Venezuela, the Venezuelan government appraised the foreign firm's assets at $800 million, whereas the firm reports they were worth between $3 and $4 billion.

7. A fuller exposition might treat this as a two- or multivariable utility function, but that would offer little gain in comprehension, and at best a modest gain in reality.

8. In some instances, the investor may be able to hide the magnitude of a big find, and thereby reduce the likelihood of expropriation.

9. It is important to note that the expropriation decision is essentially an option problem. Once the government expropriates, it cannot go back. However, if it does not expropriate, it can always do so in the future—that is, it retains option value. This implies, for example, that if there is a modest discounted expected surplus from expropriating now, it is likely to be worthwhile to wait. Such considerations, and the difficulty for the firm in judging how the government thinks about them and weighs them, help create the uncertainty surrounding $f(\Pi)$. Consider the following numerical example, with all costs and benefits computed on a discounted expected value basis. Current benefits are 100, and costs are 98. But posit that benefits are uncertain and that there is a 50-50 chance that benefits will go to 110 or 90. Expropriating now gives an expected surplus of 2, namely 100 − 98. But waiting, and only expropriating if benefits go to 110, gives an expected

surplus of 0.5(110 – 98) = 6. As with option problems in general, the greater future uncertainty is, the more worthwhile it is to preserve one's option, in this case not to expropriate now.

10. Our use of variance implicitly assumes that the profit distribution has just two parameters.

11. Note also the interaction with an auction on a profit cap as envisioned by Engel and Fischer. If firms can influence the distribution of returns, or if different firms will have different distributions for the same resource, such an auction may be inefficient. It will tend to select a firm that has compressed returns or can easily compress returns.

12. If the function relating expected return to risk is well behaved—that is, the same increment in risk reduction entails a greater loss in expected return the further the return is from the maximum return—risk aversion will compound the losses due to GRAB avoidance.

13. It also must be that the firm does not have another investment level that yields a greater expected return. Given that the government can monitor investment, it could presumably penalize an alternative superior investment level.

14. Matters would be more complex, but not fundamentally different, if I were also subject to choice.

15. The alert reader will have noticed the importance of our assumptions. If the government could have paid off more, basically it would have made an enormous payment in very unlikely circumstances. Beyond the political problem with such a scheme, it would induce the firm to choose an investment to the right of the mean-maximizing variance, hardly what the government wants. Our assumption that the government payment is small relative to expected losses from a GRAB also prevents this problem. Absent assumption 3, the government should provide some of its incentive in the lower tail of outcomes, outcomes that are also more likely when a high-variance investment is made. Payments for lower-tail outcomes would bring additional complications—for example, if firms had the ability to reduce their profits (i.e., free disposal).

16. If the curve relating mean to variance has an internal maximum, there is the danger that the firm would choose a variance above V^*, the level that maximizes the mean. The government would counter this by paying a high amount for a high realization, but penalizing even more highly a slightly more extreme low realization. This would prevent the firm from "shooting" by choosing an excessively high variance. With careful choice of payoffs in both tails, the government can ensure that the firm chooses V^*.

17. Obviously, f'' cannot be positive everywhere, because otherwise f would ultimately exceed 1.

18. The expected externality approach normally does not allow one player's private and unverifiable information to enter another player's payoff function. Our example got around that problem by charging the firm when it built Big for the cost of its externality for the marginal value of Π^*. This system will work unless the government's direct payoff from the firm's private information both falls as the firm's direct payoff rises, and also falls more rapidly than the firm's payoff rises.

19. Note that not only does the magnitude of the $f(\Pi)$ curve matter, but so does its slope in critical regions.

20. This is the flip side of the Engel-Fischer approach of having the government cap the firm's profits.

21. The function $q(\Pi)$ is actually identical to the $p(\Pi)$ function met earlier when $p(\Pi)$ is negative, as it is for larger Π in figure 6.3.

References

Arrow, Kenneth J. 1985. "The Economics of Agency." In J. Pratt and R. Zeckhauser, eds., *Principals and Agents: The Structure of Business*, 37–51. Cambridge, MA: Harvard Business School Press.

Bohn, Henning, and Robert T. Deacon. 2000. "Ownership Risk, Investment, and the Use of Natural Resources." *American Economic Review* 90(3): 526–549.

Chatterjee, Kalyan, John W. Pratt, and Richard J. Zeckhauser. 1978. "Paying the Expected Externality for a Price Quote Achieves Bargaining Efficiency." *Economics Letters* 1(4): 311–313.

Che, Jiahua, and Yingyi Qian. 1998. "Insecure Property Rights and Government Ownership of Firms." *Quarterly Journal of Economics* 113(2): 467–496.

Di Tella, Rafael, Juan Dubra, and Robert MacCulloch. 2007. *A Resource Belief-Curse: Oil and Individualism.* Harvard Business School Working Paper No. 08-035.

Engel, Eduardo M. R. A., and Ronald D. Fischer. 2008. *Optimal Resource Extraction Contracts under Threat of Expropriation.* NBER Working Paper No. W13742.

Engel, Eduardo M. R. A., Ronald D. Fischer, and Alexander Galetovic. 2001. "Least-Present-Value-of-Revenue Auctions and Highway Franchising." *Journal of Political Economy* 109(5): 993–1020.

Jacoby, Hanan G., Guo Li, and Scott Rozelle. 2002. "Hazards of Expropriation: Tenure Insecurity and Investment in Rural China." *American Economic Review* 92(5): 1420–1447.

Luttmer, Erzo F. P., and Richard J. Zeckhauser. 2008. *Schedule Selection by Agents: From Price Plans to Tax Tables.* NBER Working Paper No. W13808.

Mahajan, Arvind. 1990. "Pricing Expropriation Risk." *Financial Management* 19(4): 77–86.

Pratt, John W., and Richard Zeckhauser. 1987. "Incentive-Based Decentralization: Expected-Externality Payments Induce Efficient Behaviour in Groups." In George R. Feiwel, ed., *Arrow and the Ascent of Modern Economic Theory*, 439–483. New York: New York University Press.

Rodrik, Dani, and Richard Zeckhauser. 1988. "The Dilemma of Government Responsiveness." *Journal of Policy Analysis and Management* 7(4): 601–620.

Schelling, Thomas C. 1960. *The Strategy of Conflict.* Cambridge, MA: Harvard University Press.

Schwartz, Eduardo S., and Anders B. Trolle. 2008. "Pricing Expropriation Risk in Natural Resource contracts: A Real Options Approach." Paper prepared for Conference on Populism and Natural Resources, John F. Kennedy School of Government, Harvard University, November 1–2, 2007.

Shleifer, Andrei, and Robert W. Vishny. 1994. "Politicians and Firms." *Quarterly Journal of Economics* 109(4): 995–1025.

Tomz, Michael, and Mark L. J. Wright. 2008. *Sovereign Theft: Theory and Evidence about Sovereign Default and Expropriation?* CAMA Working Papers 2008-07. Australian National University, Centre for Applied Macroeconomic Analysis.

Walter, Matthew. 2008. "Venezuela's Chavez Decrees Takeover of Ternium Unit." April 30. http://www.bloomberg.com/apps/news?pid=20601086&sid=aFkcqZ4TOZNc&refer=latin_america.

Zeckhauser, Richard. 1996. "Insurance and Catastrophes." *Geneva Papers on Risk and Insurance: Issues and Practice* 78: 3–21.