THE CONSERVATION MULTIPLIER

Bård Harstad

(bard.harstad@econ.uio.no)

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Abstract

Every government that controls an exhaustible resource must decide whether to exploit it or to conserve and thereby let the subsequent government decide whether to exploit or conserve. This paper develops a theory of this situation and shows when a small probability that some future government will exploit a resource leads to a domino effect with rapid exploitation. This effect leads to a multiplier that measures how a small change in parameters can have large effects. The multiplier is especially large if the government is powerful now but unlikely to be in power later. The multiplier also permits dramatic returns on lobby contributions contingent on exploitation – or on compensations contingent on conservation – when these offers are expected to continue. To best take advantage of the multiplier, I show how and when compensations should be offered to the president, the party in power, the general public, or to the lobby group.

Keywords: dynamic games, exhaustible resources, deforestation, political economy, lobbying, conservation, PES, REDD+

JEL codes: D72, C73, Q57, O13

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1. INTRODUCTION

This paper analyzes resource exploitation as a dynamic game between consecutive governments. The theory can be applied to several situations, but is especially motivated by the acceleration of deforestation in the tropics.

The deforestation rate in the Brazilian Amazon is influenced by many factors but, most of all, it is in the hands of the government. Burgess et al. (2019:2-8) analyze satellite data and find that they "*demonstrate the remarkable reach of the Brazilian state to exploit or conserve its natural resources.*" In particular, the high deforestation rates in the early 2000s were "*associated with Brazilian policies to develop the Amazon.*" However: "*This policy stance was sharply reversed in the 2006-2013 period with laws to protect the Amazon rainforest being introduced and enforced.*" After seven years with record-low deforestation rates, the deforestation rate increased, once again: "*the new Government of Dilma Rousseff introduced a New Forest Code in 2012.*" The authors find *"concrete evidence that the Brazilian state is now favoring exploitation over conservation"* (p. 2).

Recently, the deforestation rate has accelerated and it was 30 percent higher in December, 2019, relative to a year earlier.[1] The government formed by the surprise winner[2] of the 2018 presidential election, Jair Bolsonaro, has abolished conservation policies and effectively encouraged illegal deforestation. If current policies continue, the rainforest might soon be below the critical size at which it can sustain itself (Amigo, 2020).

The stakes are enormously high in the Amazon. Agricultural sectors benefit when the land is cleared, but the world community, and supporters of globally stringent climate change policies, lose. Negative externalities from forest loss and degradation cost between $2 trillion and $4.5 trillion a year according to *The Economist.*[3] Franklin and Pindyck (2018) estimate that the average marginal social cost of deforestation in the Brazilian Amazon increases from $9,000 to $35,000 per hectare when deforestation rates return to

[1] See *The New York Times*: https://www.nytimes.com/2019/12/05/world/americas/amazon-fires-bolsonaro-photos.html.

[2] *The Economist* wrote that "*most analysts had thought that the right-winger would eventually lose to someone less divisive*" and that "*his own Social Liberal Party, until now a tiny group, will have 52 seats in the 513-member lower house, up from eight in the outgoing congress.*" See https://www.economist.com/the-americas/2018/10/13/jair-bolsonaro-is-poised-to-win-brazils-presidency.

[3] September 23, 2010, where *The Economist* cites a UN-backed effort, The Economics of Ecosystems and Biodiversity (TEEB). See Strand et al. (2018) for more recent estimates.

the high levels of the early 2000s. These estimates vastly exceed the cost of conservation. Deforestation may be reduced by 50% at a cost of \$21–35 billion per year, or by 20–30% at a price of \$10/tCO2.[4]

Stakeholders are thus willing to pay to influence the decision. On one side, because deforested land allows for farming and cattle raising, the agricultural sector has for decades supported, and lobbied for, a policy that permits extensive deforestation.[5] On the other side, developed countries are increasingly offering payments in return for conservation through the United Nation program Reduced Emission from Deforestation and forest Degradation (REDD+). These payments are, in part, motivated by improvements in conservation technology (such as satellite monitoring and policing capacity). In the period 2005–2012, the Brazilian government took advantage of this technology, and the payments, and proved that deforestation can be reduced dramatically when there is a political will.[6] Norway, the biggest contributer to the REDD+ program, paid Brazil \$1.2 billion in return. In 2019, however, the compensation schemes were halted, in part because of disagreements over whether the payments should be earmarked or instead be used at the discretion of the current government.

Similar situations can be found several places on Earth. The government in any resource-rich country faces the decision over whether to exploit or conserve. If the resource is conserved, the subsequent government inherits the dilemma. One may speculate how the contemporary decision depends on the expected future exploitation vs. conservation decisions. For instance, the current government may be reluctant to conserve today if it expects that the next government in office will exploit the resource to its own benefit.

Over time, this type of decision has become more significant in several countries because of technological improvements (both in logging machinery and satellite monitoring) that give governments more influence on whether the resource will be conserved or exploited. On the one hand, the stakes have increased in the agricultural sector thanks to

[4]See, respectively, Edenhofer et al. (2014) and Busch et al. (2012). Stern (2008) found that deforestation rates can be halved for as little as \$5 per ton CO_2.

[5]See Barbier et al. (2005) and, more recently, *The Washington Post*: https://www.washingtonpost.com/world/the_americas/why-brazilian-farmers-are-burning-the-rainforest–and-why-its-difficult-for-bolsonaro-to-stop-them/2019/09/05/3be5fb92-ca72-11e9-9615-8f1a32962e04_story.html.

[6]Hansen et al. (2013) found evidence that tropical deforestation declined 2005–2012 in Brazil. For more recent evidence, see Burgess et al. (2019).

new trade agreements that enlarge the markets.[7] On the other hand, the threat of climate change and the emergence of global climate policies imply that the world community has a greater willingness to pay for conservation than before.

These developments raise a number of questions. How does the exploit vs. conserve decision depend on expected future policies? What are the roles of political stability, institutions, and of improved conservation technology and exploitation capacity? Are lobby groups taking advantage of the dynamic game between the governments? When can compensations for conservation be effective, and should they be earmarked for public goods or rather be targeted to the president, the party in power, or the lobby group?

This paper provides a theoretical framework for analyzing questions of this type. In every period, there is a president deciding on whether to exploit or conserve an exhaustible resource. If the president conserves the resource, the next-period president, who might, with some chance, represent a different party, must decide whether to continue conserving. It is valuable to conserve as well as to exploit, and I assume that the value of exploitation is always larger when one's own party is in power than when another party is in power.[8] The game ends when the resource is (fully) exploited. The model permits resource extraction to be gradual or probabilistic but, to fix ideas, suppose it is probabilistic.

Different individuals (and different presidents) can have different preferences. With sufficient heterogeneity, the current president expects that the next president will exploit with some probability. If this probability increases, the value of conserving today is diminished and the probability for exploitation already today increases. This mechanism leads to a domino, or multiplier, effect: If the probability that a future president exploits increases slightly, then the probability that the current president exploits already today can increase by a lot. The equilibrium rate of exploitation can thus be very sensitive to small changes in the parameters. The multiplier is larger if the president's party is likely to lose power and if exploitation is much more valuable to a ruling party than to the opposition (because of the possibility to spend the revenues on party perks). The

[7] Burgess et al. (2019) observe a development with "*better monitoring (through use of satellite data)*" (p. 13) and, simultaneously, a "*growing political power of the agriculture producers*" (p. 8).

[8] This is natural: Caselli and Michaels (2013:230-231) find that "*some of the revenues from oil* [in Brazil] *disappear before turning into the real goods and services they are supposed to be used for*" and "*the evidence leads us to conclude that the missing money result is explained by a combination of patronage spending/rent sharing and embezzlement.*"

equilibrium probability of exploitation, or the expected rate of extraction, can thus be much larger than it would have been if the party were certain to stay in power forever. (In that case, the multiplier would have been 1.) These results are in line with the evidence.[9]

The multiplier is also making conservation measures more effective. If a donor provides compensations in return for conservation, the president is more likely to conserve. When the current president anticipates that the compensations will make conservation more likely also in the future, then conservation becomes more valuable today, and thus the president becomes willing to conserve for a lower price. For this reason, the rate of return on compensation can be arbitrarily high, and it increases with the multiplier.

A lobby group, benefiting from exploitation, can also take advantage of the multiplier. If the lobby pays favors to a president that exploits, then any future president becomes more likely to exploit and it becomes less attractive to conserve today. The lobby makes it more expensive for the donor to conserve, but the multiplier increases with the lobby contribution (because the disagreement between the party in power and the opposition increases), and therefore the optimal compensation level for conservation increases.

The conservation multiplier depends on how the compensation payments are targeted. On the one hand, current payments may be most persuasive if the current president has full discretion regarding how the funds are to be spent. On the other hand, if the compensation benefits the general public, and not only the sitting president, then future conservation becomes more valuable to the current president (regardless of whether his party will be in or out of office). Under specified conditions, earmarking the funds can be more effective. If the lobby group is more likely to successfully influence policy over time than the current president is likely to stay in power, then the donor can benefit from paying the lobby group to not lobby.

Literature.—The present paper contributes to multiple strands of literature. Most specifically, I add a new political economy perspective to our understanding of deforesta-

[9] Bohn and Deacon (2000) found that political risk increases deforestation (but not necessarily investment-intensive resource extraction). Collier (2010:1124) wrote that: "*ministers in the transitional government in the Democratic Republic of Congo (DRC) knew that they only had around three years in office. During this period many contracts were signed with resource extraction companies conceding very generous terms in return for signature bonuses that cashed in the value of the natural assets to the society.*" The theory also predicts that the multiplier is larger when the president has a lot of discretion, as when there are few checks-and-balances. This is consistent with the empirical evidence of Collier and Hoeffler (2009), for example, who show that checks-and-balances mitigate the resource curse.

tion. There is a large literature on deforestation, and an emerging literature on deforestation compensations. Payments for environmental services (PES) can be important in many situations, and REDD+ is one special type of them.[10] Existing theories focus on contract-theoretic problems such as moral hazard (Gjertsen et al., 2016; Kerr, 2013), private information (Mason and Plantinga, 2013; Mason, 2015; Chiroleu-Assouline et al., 2012), observability (Delacote and Simonet, 2013), liquidity constraints (Jayachandran, 2013), and additionality (Jack and Jayachandran, 2019).

The strand that is more directly related to the present paper studies the political economy determinants of deforestation. Burgess et al. (2012) showed that deforestation increased in election years and after decentralization reforms in Indonesia (see Pailler, 2018, for a more recent study of Brazil). Harstad and Mideksa (2017) provided a theoretical framework to explain the evidence and how conservation contracts should be designed when there are competing jurisdictions. These frameworks are static, however, so they failed to uncover the multiplier, emphasized here.

Harstad (2016) analyzed a dynamic game between a country who prefers to exploit, and a donor who may buy the resource in order to conserve it. That game, however, did not permit rotation of political power and thus, again, it failed to uncover the multiplier emphasized in this paper.[11]

In climate and environmental economics, it is frequently argued that the expectation of a future environmental policy leads to less conservation today (Kremer and Morcom, 2000) or a worse environment ("the green paradox"; Sinn, 2008; 2012). In this paper, in contrast, the president may conserve today *exactly* because, or when, conservation is expected in the future. This political mechanism also contributes to the literature on the resource curse, investigating conditions under which natural resources are managed well (see van der Ploeg, 2011, for a survey). In particular, Robinson et al. (2006) show that an incumbent extracts more if he is unlikely to be reelected. However, expectations regarding future policies are irrelevant in their two-period model.[12]

[10] See Engel et al. (2008) for PES more generally, or Karsenty (2008) and Parker et al. (2009) for a discussion of the difference between RED, REDD, and REDD+.

[11] That paper was, in part, motivated by the model in Harstad (2012) where conditions were derived under which it is optimal to "buy coal" and conserve it, as a climate policy. Thus, the papers differ in several ways. For example, Harstad (2016) relied on complete information and mixed-strategy equilibria and permitted neither lobbying nor alternative targets for the funding.

[12] Ryszka (2013) allows for multiple periods, Long (1975) finds extraction to be larger when one fears

Dynamic games between successive governments have been studied elsewhere in economics, of course. It is well known that political turnover leads to less investments in state capacity (Besley and Persson, 2009; 2010), the accumulation of debt (Persson and Svensson, 1989; Alesina and Tabellini, 1990; Tabellini, 1991; Battaglini and Coate, 2008), and to time inconsistency (Amador, 2003; Bisin et al., 2015; Chatterjee and Eyigungor, 2016; Harstad, 2020).[13] However, these decisions (f.ex., accumulation of debt) are reversible, while for the multiplier effect, in this paper, the decision to exploit must be irreversible.[14,15] In addition, my emphasis on the role of lobbies and stakeholders influencing the decisions in these dynamic political economy games is unprecendented, as far as I know.

Multiple lobby groups are naturally considered already in the political economy literature. The seminal result by Grossman and Helpman (1994) is that efficient trade occurs when all groups are lobbying. However, this result fails to hold in the present exploitation vs. conservation game: In contrast, the analysis below uncovers a fundamental asymmetry in the influence between the lobby paying for action (i.e., exploitation) and the stakeholder paying for inaction (i.e., conservation), because the first lobby only needs to pay the president one single time to succeed, whereas the stakeholder paying for conservation needs to pay in every period. The cost is thus higher for this stakeholder which, therefore, is less likely to succeed.[16]

Outline.—The next section presents the model with rotation of political power and

nationalization, van der Ploeg and Rohner (2012) show that extraction is larger if the resource fuels conflicts, Mehlum et al. (2006) find that the curse depends on the quality of institutions, and Brollo et al. (2013) show that oil shocks in Brazil influence the electoral candidate selection.

[13] I follow most of this literature by assuming that the reelection probability is exogenous. In Battaglini and Harstad (2020), however, incumbents sign treaties and invest in technologies in order to influence future elections.

[14] That said, Alesina and Drazen (1991) do model stabilization policies as a once-and-for-all irreversible policy decision. In their paper, each policymaker hopes that another policymaker will end the game (by stabilizing the economy), while in the present paper each policymaker hopes that the other policymakers will *not* end the game. This difference is key and leads to dramatically different results.

[15] There is a theoretical literature on dynamic contribution games (see Marx and Matthews, 2000, and subsequent papers), but the present game is very different since every player fears that later players will end the game (by exploiting the resource). In the contribution games literature, in contrast, each player fears that subsequent players will not contribute, i.e., that the game will continue for a long time. Given that the game here is a stopping game, it is also very different from the literature on dynamic common pool problems, typically focusing on the steady state when the resource is renewable (see, for example, Nowak, 2006, and the subsequent literature).

[16] This inefficiency does not arise in the models by Schopf and Voss (2017; 2019) who analyze lobbying of a long-lived government or planner extracting the resource.

discusses the exploitation multiplier. Section 3 shows how the analogous conservation multiplier can be taken advantage of - not only by a donor paying for conservation - but also by a lobby group paying for exploitation. Section 4 shows when the donor achieves cost-effective conservation by paying the party, the public, or the lobby group, instead of paying the president. Section 5 extends the model in several directions, Section 6 concludes, and the Appendix contains all proofs.

2. The Dynamics of Conservation and Exploitation

2.1. *A Stopping Game*

Players.—Every period t is associated with a president P_t ("he"). The individual president P_t will not be the president in later periods. However, the model can distinguish between presidents, parties, and the opposition, and the president might be associated with a political party. The party in power at time t is out of office in any later period with probability $p \in [0, 1]$. If $p = 0$, there is no chance for any rotation of power.

Actions.—P_t decides only on $s_t \in [\underline{x}, \overline{x}] \subseteq [0, 1]$. Decision variable s_t can be interpreted as the probability of exploiting an exhaustible resource, such as a biodiverse tropical forest. Alternatively, as I will explain in the next subsection, s_t can be interpreted as the fraction of the resource that is extracted at time t. When s_t is interpreted as a fraction, it is reasonable to assume that there are boundaries to how fast the resource can be exploited and to the extent to which it can be conserved. However, also when s_t is interpreted as a probability, it may be difficult for P_t to guarantee with certainty that the resource is, or is not, exploited. For these reasons, I permit $\underline{x} > 0$ and $\overline{x} < 1$, but the reader is welcome to restrict attention to the simpler situation in which $\underline{x} = 0$ and $\overline{x} = 1$.

Payoffs.—There is a benefit from exploiting the resource. To allow for a conflict of interest, let $\overline{b} > 0$ be the benefit for the party in power, and $b \geq 0$ for everyone not in power. For the most part, I will assume that $\Delta \equiv \overline{b} - b > 0$, meaning that any P_t benefits more if he, or his party, exploits the resource, than if another party exploits the resource. Since $\Delta > 0$ measures the ruler's additional benefit of exploitation, it might be reasonable that Δ is correlated with the amount of corruption in the country, or that

Δ will be limited if there are sufficient checks-and-balances. (Similarly, the amount of discretion, $\overline{x} - \underline{x}$, may also be limited by institutional checks-and-balances.) In Section 5, I discuss applications of the model in which $\Delta < 0$ is natural, and how the results would change in that case.

Even though the president at time t will not be the president at later times, there may be some chance that P_t can enjoy $\overline{b}$, rather than b, if the resource is exploited in the future. To be specific, suppose P_t is associated with a political party and enjoys $\overline{b}$, rather than b, if and only if this party exploits the resource in the future. When $p \in [0, 1]$ is the probability that the current president's party is out of office in any later period, P_t enjoys $\overline{b}$ if he extracts the resource, but expects $pb + (1-p)\overline{b} \leq \overline{b}$ if the resource is exploited later.

Although Section 2.5 explains how the model can permit heterogeneous political parties, I will otherwise not consider heterogeneity in p. If there are n identical parties, then we may have $1 - p = 1/n$, for example, but the reader is free to restrict attention to the simple case in which $p = 1$. (In that case, the party plays no role.)

There is also a cost associated with exploiting the resource or, equivalently, there is a benefit from conservation. The per-period payoff to P_t if the resource is conserved at time $\tau \geq t$ is $c_P > 0$. Thus, P_t's payoff from conserving indefinitely is $c_P/(1-\delta)$ when $\delta \in (0, 1)$ measures the common discount factor.

To allow future decisions to be uncertain, the subscript on c_P indicates that various individuals and presidents may value conservation differently. To model this uncertainty, let $c_P = \underline{c} + \theta_t \in [\underline{c}, \underline{c} + \sigma]$, where $\underline{c} > 0$ is a common component while θ_t characterizes the type of president in power at time t. Every θ_t is i.i.d. uniformly on $[0, \sigma]$.

The model and the results stay unchanged if the gain from extraction, b, instead of $\underline{c}$, were heterogeneous and uncertain in this way, and also if $\underline{c}$, instead of b, were dependent on whether one's own party makes the decision.[17] Section 5 shows that other types of uncertainties (regarding the resource price, for example) lead to similar results.

Timing.—There is an infinite number of periods. The identity of P_t is determined period t. Technically, this means that θ_t is drawn from $[0, \sigma]$. Thereafter, P_t decides on

[17] The Appendix permits both b and c to depend on whether one's own party acts, and they can also be different for P_t when he is the president and when he is not.

$s_t \in [\underline{x}, \overline{x}]$ and receives the expected payoff $s_t\overline{b} + (1 - s_t)(\underline{c} + \theta_t)$. With probability s_t, the exploitation game ends after period t. With probability $1 - s_t$, the game continues to period $t + 1$. Then, and in any future period, another (identical) party is in office with probability p. Subsection 2.5 and Section 5 let the parties be heterogeneous and p to be endogenous.

Equilibrium Concept.—The game is stationary, every subgame is equivalent, and the history is "payoff irrelevant" (as long as the resource has not been exhausted). Thus, I will look for an equilibrium in stationary strategies. In fact, if later presidents can observe the outcome only, and not the chosen probability $s_t \in [\underline{x}, \overline{x}]$, then every subgame-perfect equilibrium (SPE) must be stationary. Hence, P_t's strategy, $s_t(\theta_t)$, is a function of θ_t alone. Since the distribution of θ_t is independent of time, the probability that any later president exploits is constant over time. Let x be this stationary probability. If P_t conserves, his continuation value starting at any later period is:

$$V^P = pbx + (1-p)\overline{b}x + (1-x)\left(c_P + \delta V^P\right) = \frac{pbx + (1-p)\overline{b}x + (1-x)c_P}{1 - \delta(1-x)}. \quad (1)$$

Anticipating V^P, P_t solves:

$$\arg\max_{s_t \in [\underline{x}, \overline{x}]} x_t\overline{b} + (1 - x_t)\left(c_P + \delta V^P\right). \quad (2)$$

2.2. *Probabilistic vs. Gradual Extraction*

As an alternative to interpreting s_t as the probability of exploitation, it can be interpreted as the fraction that is extracted from a resource stock S_t, so that $S_{t+1} = (1 - s_t) S_t$. For s_t to be Markov perfect, s_t, and thus x, cannot be functions of the stock when the stock is payoff irrelevant. The stock is payoff irrelevant as long as when later presidents do not condition their strategies on the stock, then the current president does not benefit from conditioning s_t on S_t. To see that the stock is indeed payoff irrelevant, note that *if* the future x is constant over time, then $S_\tau = (1 - x)^{\tau - t} S_t$ and P_t's continuation value at

$\tau > t$ can be written as:

$$\sum_{\kappa=\tau}^{\infty} \delta^{\kappa-\tau} \left[pbxS_\kappa + (1-p)\,\overline{b}xS_\kappa + (1-x)\,S_\kappa c_P\right]$$
$$=\sum_{\kappa=\tau}^{\infty} \delta^{\kappa-\tau} (1-x)^{\kappa-\tau}\, S_\tau \left[pbx + (1-p)\,\overline{b}x + (1-x)\,c_P\right]$$
$$=S_\tau \frac{pbx + (1-p)\,\overline{b}x + (1-x)\,c_P}{1-\delta\,(1-x)} = S_\tau V^P,$$

where V^P is as in (1). Anticipating this, P_t solves:

$$\arg\max_{s_t \in [\underline{x},\overline{x}]} x_t S_t \overline{b} + (1-x_t)\,S_t c_P + \delta\,(1-x_t)\,S_t V^P,$$

which is the same s_t as in (2). Hence, a Markov strategy s_t does not depend on S_t.

It follows that if s_t is interpreted as the *fraction* of the remaining resource that is exploited, then the set of Markov-perfect equilibria (MPEs) coincides with the set of SPEs we obtain when s_t is interpreted as the *probability* that P_t exploits the resource (if later presidents can observe whether the resource is exploited, but not the past s_t's). With this, $\underline{x}$ and $\overline{x}$ can be interpreted as the minimum and maximum fractions, respectively, that can be exploited in any given period.

Although the model permits both interpretations, it is helpful to fix ideas and refer to s_t as the probability. (After all, and as discussed in Section 5, if s_t is a fraction, then there might be other SPEs in addition to the MPEs emphasized in the following analysis. These SPEs cease to exist when s_t represents a probability.)

2.3. *Strategies*

When P_t's continuation value is given by (1), the solution to problem (2) is very simple. P_t's best and equilibrium strategy, $s_t\,(\theta_t)$, is:

$$\underline{x} \text{ if } \theta_t \geq \theta\,(x)\,, \text{ and}$$
$$\overline{x} \text{ if } \theta_t \leq \theta\,(x)\,, \text{ where}$$
$$\theta\,(x) \equiv \delta p \Delta x + (1-\delta)\,\overline{b} - \underline{c}. \quad (3)$$

The probability of exploitation, $x_t \equiv \mathrm{E}_{\theta_t} s_t(\theta_t)$, is:

$$x_t = \underline{x}\Pr(\theta_t \geq \theta(x)) + \overline{x}\Pr(\theta_t \leq \theta(x)).$$

Given that θ_t is uniformly distributed on $[0,\sigma]$, we can easily see when the equilibrium level for x_t depends on the expected x in later periods:

$$x_t(x) = \left\{ \begin{array}{cl} \underline{x} & \text{if } \theta(x) \leq 0 \\ \underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\theta(x) & \text{if } \theta(x) \in [0,\sigma] \\ \overline{x} & \text{if } \theta(x) \geq \sigma \end{array} \right\}. \tag{4}$$

Proposition 1.

(i) If $p\Delta = 0$, *current exploitation is independent of future exploitation:* $x_t(x) = x_t(0)$.

(ii) If $p\Delta > 0$, *current exploitation increases with future exploitation:* $\partial x_t(x)/\partial x > 0$.

The First Best.—To evaluate the result, it is useful to compare it to the first-best outcome for x_t. For the utilitarian first-best outcome, if the payoff of the ruling party is negligible relative to everyone else, it is optimal to increase exploitation (from $\underline{x}$ to $\overline{x}$) if and only if:[18]

$$(1-\delta)b > c, \tag{5}$$

where $c \equiv \underline{c}+\sigma/2$, independently of the future exploitation probability, x. By comparison, P_t exploits if $(1-\delta)\overline{b}+\delta p\Delta x > \underline{c}+\theta_t$. Thus, even if $p\Delta x = 0$, P_t's preference is different from that of the opposition because of the additional value $(\overline{b}-b)$ of exploitation for the party in power, and because θ_t can be different from the average shock (which is $\sigma/2$).

Part (i) of the proposition shows that, as in the first best, x_t is independent of the future x when $p = 0$ or $\Delta = 0$. If P_t's party will always stay in power, or if there is no conflict of interest between the party in power and the opposition, then P_t's decision does not depend on what later presidents are expected to do. This is intuitive: The level of $x_t(x)$ is determined by the type that is indifferent between exploiting and conserving. The type that is indifferent now is also indifferent regarding whether his party will exploit later, and thus that later decision is of no consequence (Observation 1 in the Appendix elaborates on this).

Part (ii) is intuitive as well: If P_t conserves, it is because P_t hopes to enjoy the

[18] By comparison, P_t exploits if $(1-\delta)\overline{b}+\delta p\Delta x > \underline{c}+\theta_t$.

conservation benefit c_P when the opposition rules. But if future presidents are likely to exploit, then P_t strictly prefers to exploit right now if he fears to lose power ($p > 0$) and, with that, some of the gains (Δ) from exploiting the resource. In this case, the expectations of future policies influence the policy today, and the influence is significant when $p\Delta$ is large.

2.4. *Equilibria*

The stationary equilibrium is characterized by $x_t(x) = x$. For the equilibrium x to be interior in $(\underline{x}, \overline{x})$ and stable, we must have:

$$x_t(\underline{x}) > \underline{x}, \tag{A1}$$

$$x_t(\overline{x}) < \overline{x}. \tag{A2}$$

With (3)-(4), (A1) and (A2) are, respectively, equivalent to:

$$\delta p \Delta \underline{x} + (1-\delta)\,\overline{b} > \underline{c},$$
$$\delta p \Delta \overline{x} + (1-\delta)\,\overline{b} < \underline{c} + \sigma.$$

Proposition 2. *The set of equilibrium outcomes can be one of four types:*
(i) Suppose (A1) fails. There exists a stable equilibrium with $x = \underline{x}$*.*
(i-1) If (A2) holds, this is the unique equilibrium outcome.
(i-2) If (A2) fails, there is also a stable equilibrium with $x = \overline{x}$*.*
(ii) Suppose (A1) holds. There is no equilibrium with $x = \underline{x}$*.*
(ii-1) If (A2) fails, the unique equilibrium outcome is $x = \overline{x}$*.*
(ii-2) If (A2) holds, the unique equilibrium outcome is:

$$x = \frac{\frac{\sigma \underline{x}}{\overline{x}-\underline{x}} + (1-\delta)\,\overline{b} - \underline{c}}{\frac{\sigma}{\overline{x}-\underline{x}} - \delta p \Delta} \in (\underline{x}, \overline{x})\,. \tag{6}$$

The four cases are illustrated in Figure 1 and discussed in the following.

Self-fulfilling Expectations.—First, suppose $\underline{c}$ is so large that (A1) fails: $\underline{c} > (1-\delta)\,\overline{b} + \delta p \Delta \underline{x}$. If $\underline{x} = 0$, this inequality is simply $\frac{\underline{c}}{1-\delta} > \overline{b}$. Under this condition, no president

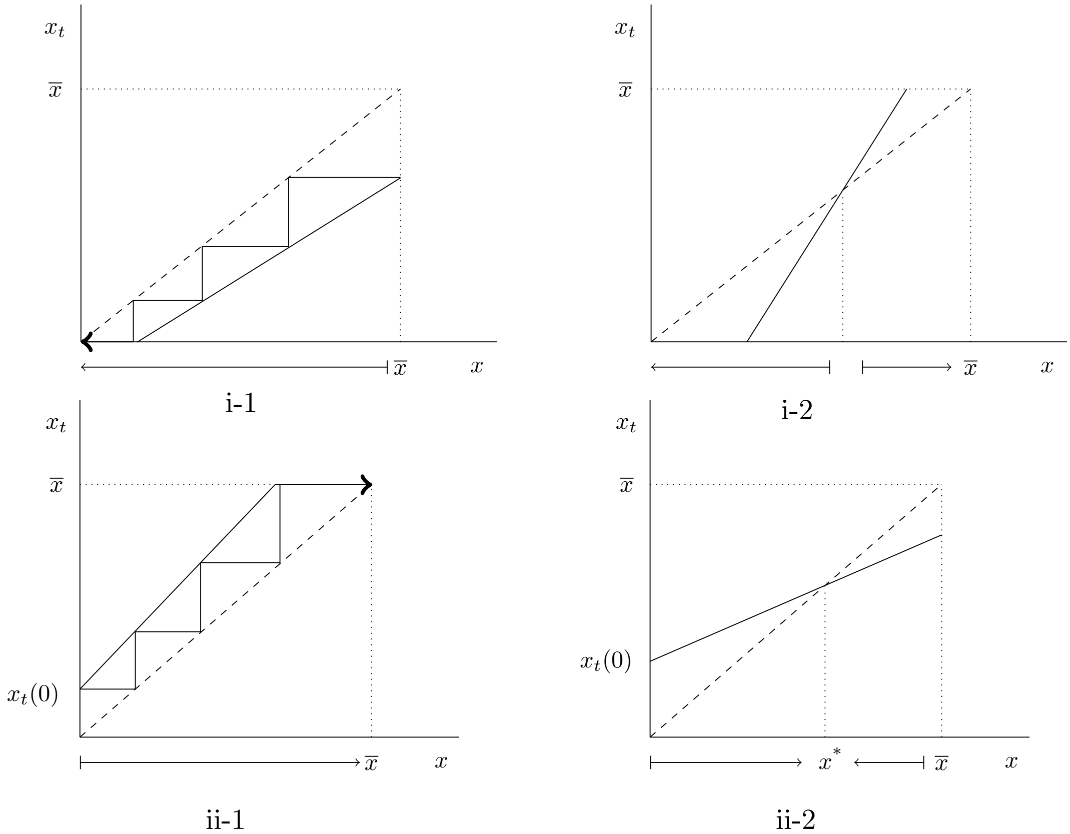

Figure 1: *In equilibrium,* $x_t = x$.

would ever exploit the resource if the probability (p) for the party to lose power were zero. In line with this preference, the resource is never exploited in case (i-1). However, if $p\Delta\overline{x}$ is large, (A2) fails and we enter case (i-2) and a situation with self-fulfilling expectations: While no president exploits if later presidents are expected to conserve, everyone exploits if it is expected that later presidents will exploit. In this case, there are multiple equilibria. Note that this situation can arise only if there is a sufficiently large probability (p) for losing power later, and if the conflict (Δ) between the rulers and the opposition is large. Of the two equilibria, everyone prefers the equilibrium $x = \underline{x}$, but $x = \overline{x}$ is nevertheless also a stable equilibrium.

A Domino Effect.—Now, assume (A1) holds, so that there is always some chance that P_t exploits (when θ_t is very small). If (A2) fails, the only equilibrium is $x = \overline{x}$. Remarkably, $x = \overline{x}$ is the only equilibrium even if $x_t(0) > 0$ is arbitrarily small, i.e., if a long-lived party (that stayed in power with certainty) would exploit the resource with a very small probability. The intuition for why $x = \overline{x}$ nevertheless is the only equilibrium is due to a domino effect: If P_t is expected to exploit with a small but positive probability, then at time $t-1$, exploitation becomes optimal for a set of θ_{t-1}'s so that the probability for exploitation at $t-1$ is larger than the probability was at time t. Anticipating this, the incentive to exploit is even larger at time $t-2$, and so on, until all incentives for conservation unravel and exploitation becomes attractive even for the most conservation-friendly president. The unraveling path is illustrated in panel ii-1 in Figure 1.

If both (A1) and (A2) hold, the domino effect converges and it does not lead to a complete unraveling of the conservation incentives. This situation is the relevant one if there is sufficient uncertainty and always some chance that the presidents may prefer to conserve, no matter what the future may bring, but it is also possible that some president, at some point in time, may prefer to exploit, even if he would hold power forever. When none of these possibilities can be ruled out, we are in case (ii-2), with the unique stable equilibrium outcome $x_t(x) = x \in (\underline{x}, \overline{x})$. Since only this equilibrium is sensitive to small changes in the parameters, it allows for particularly interesting comparative statics. To study them, I henceforth assume that (A1) and (A2) hold.

The Multiplier.—Some of the properties of this equilibrium are quite natural. As one would expect, the probability of exploitation is larger if $\overline{b}$ is large and $\underline{c}$ is small. More interestingly, note that while $x_t(0)$ measures the equilibrium probability for exploitation if $p = 0$, the equilibrium probability can be much larger when there is a chance $(p > 0)$ that parties rotate being in office. The ratio of the two is:

$$\frac{x}{x_t(0)} = \frac{1}{1 - \delta p \Delta (\overline{x} - \underline{x}) / \sigma} > 1 \text{ when } p\Delta > 0. \tag{7}$$

The number on the right-hand side can be referred to as the exploitation multiplier, since it measures the factor that $x_t(0)$ must be multiplied by in order to obtain the equilibrium x, which is strictly larger than $x_t(0)$ only because $p\Delta > 0$. The multiplier also measures how x changes in parameters $\underline{c}$ and $\overline{b}$, relative to how $x_t(0)$ changes in these parameters. This difference can be very large because while there is a direct effect from, for example, a larger $\underline{c}$ on x_t (so that $x_t(x)$ is reduced to x' in Figure 2, even for a fixed x), the equilibrium x_t is reduced all the way to x'' thanks to the indirect effect that every future x also is reduced when $\underline{c}$ is larger.

So, although the domino effect converges to an interior solution for x when (A1) and (A2) hold, the domino effect can still be quite large. Although $x_t(x)$ is linear in $p\Delta$, x is

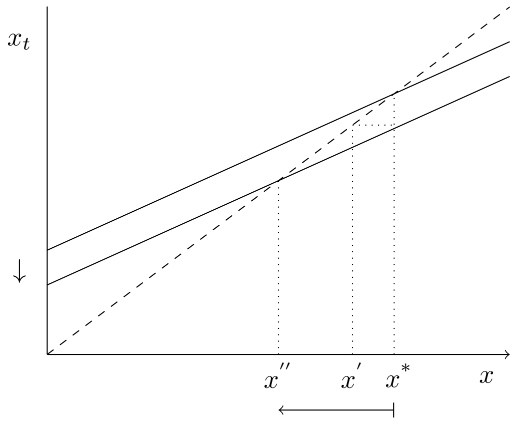

Figure 2: *A larger c reduces x all the way to x'' - thanks to the multiplier.*

convex in $p\Delta$ because the multiplier increases in $p\Delta$. The multiplier can increase without bounds:

$$\frac{1}{1-\delta p\Delta\left(\overline{x}-\underline{x}\right)/\sigma}\uparrow\infty \text{ when } p\uparrow\frac{\sigma/\delta\Delta}{\overline{x}-\underline{x}}.$$

Of course, as the multiplier increases, the equilibrium will eventually be characterized by (ii-1) in Proposition 1, where $x=\overline{x}$: the unique equilibrium x reaches $\overline{x}$ as soon as

$$\delta p\Delta\overline{x}\geq\sigma-(1-\delta)\,\overline{b}+\underline{c},$$

even though $x_t\,(0)$ can be arbitrarily small.[19]

Exploitation Technology and Conservation Technology.—The threshold $\underline{x}$ can be interpreted as the minimal fraction (or probability) of extraction that we face, even if P_t attempts to conserve. For tropical deforestation, illegal logging (and fires) can make it difficult to reduce x all the way to zero. However, better monitoring technology can reduce $\underline{x}$. The effect of a lower $\underline{x}$ is that x is reduced for two reasons. The direct effect is that every time conservation is attempted (i.e., when $\theta_t>\theta\,(x)$), it is more likely to succeed. In addition, when the future x is reduced (because of the lower $\underline{x}$), then it becomes more attractive to conserve now, and the threshold $\theta\,(x)$ is reduced. This indirect effect is large when the multiplier is large. The multiplier, in turn, is large when $\underline{x}$ is small. Therefore, the effect on conservation accelerates when $\underline{x}$ falls. Technically,

[19] The multiplier here is very different from the ecological multiplier measuring how deforestation negatively affects the standing forest because of fragmentation and dryness (Strand, 2017).

although $1 - x_t(x)$ is linear in $\underline{x}$, $1 - x$ is convex in $\underline{x}$:

$$\frac{\partial^2 (1 - x)}{(\partial \underline{x})^2} > 0.$$

The upper boundary $\overline{x}$ can be interpreted as the speed (or, alternatively, as the probability) at which exploitation may occur if P_t prefers to exploit the resource. For tropical forests, $\overline{x}$ is limited by the capacity to log (which, in turn, is limited by the number of machines and the amount of specialized labor). With technological progress, or economic development, deforestation can occur at a higher speed. A larger $\overline{x}$ increases x for two reasons. The direct effect is that if P_t prefers exploitation, he can exploit faster. The indirect effect is that when the future x is larger because of the direct effect, then exploitation becomes more attractive now (in that $\theta(x)$ increases). The indirect effect increases with the multiplier, and the multiplier increases with $\overline{x}$. So, although $x_t(x)$ is linear in $\overline{x}$, x is convex in $\overline{x}$:

$$\frac{\partial^2 x}{(\partial \overline{x})^2} > 0.$$

Since $[\underline{x}, \overline{x}]$ represents the discretion, or power, of the president, $[\underline{x}, \overline{x}]$ can also be larger in countries with weak political institutions since various checks-and-balances often limit the power of the executive.

Corollary 1. *If the technologies are more effective, or institutions are weaker, the multiplier $x/x_t(0)$ is larger.*

2.5. *Remarks on Heterogeneous Parties and Elections*

Although Sections 3-4 draw on the basic model above, it is worth noting how a generalization of the model can shed light on the recent development in Brazil. (For details, see Section 5.1.)

Heterogeneous Political Parties.—If we have two parties, A and B, and p^i measures the probability that $i \in \{A, B\}$ is out of office in any given period, then (4) holds for $x_t^i(x^j)$ if $\theta(x)$ in (3) is replaced by:

$$\theta^i\left(x^j\right) \equiv \delta \Delta p^i x^j + (1 - \delta)\,\overline{b}^i - \underline{c}^i,\ j \neq i,\ i \in \{A, B\}. \tag{8}$$

Now, we have two equations to determine the stationary x^A and x^B.

The difference between x^A and x^B is interesting. If party B, for example, benefits more from exploitation in that $\overline{b}^B$ increases or $\underline{c}^B$ decreases, then that increases the equilibrium x^B and, therefore, also the equilibrium x^A. If the parties only differ in p^i, then $x^A < x^B < 0$ if and only if $p^A < p^B$.

Corollary 2. *The minority party (with the largest* p^i*) is more likely to exploit.*

Elections.—Since both parties exploit more than they would have preferred under commitment (or if $p^i = 0$), it is reasonable that voters prefer more conservation. In that case, if $x^A < x^B$, the voters elect A with a larger probability than B, so $p^A < p^B$. Since $p^A < p^B$ caused $x^A < x^B$ in the first place, there can be multiple (self-enforcing) equilibria: Party B exploits more because B is unlikely to be in power later, and B is unlikely to be (re)elected because the voters rationally expect B to exploit more. When B anticipates that it is handicapped in the election because of the mere existence of the resource, B has an additional incentive to exploit fast, so as to eliminate this handicap.

These predictions are formalized and proven later in the paper. Here, it suffices to note that they are in line with the recent development in Brazil. As mentioned in the Introduction, president Bolsonaro was a surprise winner, he may not be expected to remain in office after the next election, nor has he declared an intention to seek reelection.[20] The high deforestation rate tolerated by the current government is thus consistent with the theory. This consistency is reassuring before we employ the basic model to investigate optimal conservation measures.

[20]For example, President Bolsonaro claimed in 2019 that "*I'm not worried about reelection. The day I worry about reelection, I turn into a guy just like the others before me*," according to https://noticias.uol.com.br/meio-ambiente/ultimas-noticias/redacao/2019/08/26/bolsonaro-questiona-intencoes-por-tras-de-ajuda-internacional-para-amazonia.htm

3. Payments and Lobbying For or Against Exploitation

3.1. *Paying for Conservation*

The Conservation Multiplier.—The exploitation multiplier can just as well be referred to as the conservation multiplier, since it coincides with the percentage increase in the probability of conservation $(1-x)$ when the resource may be conserved also in the future, relative to the probability of conservation today if the resource were to be exploited in the very next period. Simple algebra verifies that:

$$\frac{1-x}{1-x_t(1)} = \frac{x}{x_t(0)} = \frac{1}{1-\delta p\Delta\left(\overline{x}-\underline{x}\right)/\sigma}.$$

So, just as the multiplier amplifies the incentives to exploit the resource, it can amplify the effects of compensation for conservation.

Effects of Compensations.—Developed countries are increasingly offering compensation in return for verified reductions in deforestation rates. To start with, I assume that the compensation is directly beneficial only for the president (Section 4 relaxes this assumption). A compensation k to P_t, conditional on conservation at time t, implies that P_t prefers to exploit only when:

$$\begin{aligned}\overline{b} &> k + c_p + \delta V^P = k + \underline{c} + \theta_t + \delta\frac{pbx + (1-p)\,\overline{b}x + (1-x)\left(\underline{c}+\theta_t\right)}{1-\delta(1-x)} \Leftrightarrow \\ \theta_t &< \theta_k(x) \equiv \delta p\Delta x + (1-\delta)\,\overline{b} - \underline{c} - k\left[1-\delta(1-x)\right]. \qquad (9)\end{aligned}$$

When k increases, $\theta_k(x)$ decreases and so does the set of presidents who exploit. With (9), replacing (3), $x_t(x)$ continues to be given by (4). That is, for any given future x, x_t decreases in k. The reduction in x_t is the immediate and direct effect of the compensation.

There is also an indirect effect at play when k is expected to be offered to future presidents who conserve, since the reduced future x contributes to a reduced x_t, as observed in Proposition 1. Consequently, the total effect of a per-period payment k on x can be much larger than the effect of k, in period t only, on x_t. In other words, the presence and anticipation of future compensations help a donor to obtain what it seeks today (i.e., conservation) at a lower cost. When k is paid to every future P_t who conserves, then $x_t(x) = x$ is:

$$x = \frac{\frac{\sigma \underline{x}}{\overline{x}-\underline{x}} + (1-\delta)\,\overline{b} - \underline{c} - (1-\delta)\,k}{\frac{\sigma}{\overline{x}-\underline{x}} - \delta p \Delta + \delta k}, \tag{10}$$

if we throughout this section sticks to the assumption that x is interior in $[\underline{x}, \overline{x}]$. (Section 4 relaxes this assumption and studies the corner solution $x = \underline{x}$.)

Optimal Compensation.—Let D ("she") be a long-lived donor and $d > 0$ the per-period damage avoided in every period in which the resource is conserved. With a linear per-period cost of k, D's continuation payoff is:

$$V^D = (1-x)\left(d - k + \delta V^D\right) = (d-k)\,\frac{1-x}{1-\delta\,(1-x)}. \tag{11}$$

When we substitute for x, as given by (10), and derive the optimal k, we arrive at our next result.

Proposition 3. *The optimal $k \geq 0$, from D's point of view, increases in $p\Delta$:*

$$k^* \equiv \arg\max_k V^D = \max\left\{0, \frac{1}{2}\left[d - \sigma \frac{1-\underline{x}}{\overline{x}-\underline{x}} + \delta p \Delta + (1-\delta)\,\overline{b} - \underline{c}\right]\right\}. \tag{12}$$

Intuitively, and as evident from the first two terms in (12), k^* increases in d and in $(\overline{x} - \underline{x})$. Thus, it is optimal to offer more if P_t has access to a more effective exploitation technology or conservation technology.

A larger third term in (12), $\delta p \Delta$, increases the multiplier, the effectiveness of the compensation, and therefore the optimal k^*. Simply put: It is optimal to offer more for conservation if the party in power is likely to lose power in the future, or if the disagreement between the ruling party and the opposition is large.

The optimal k^* is smaller when $(1-\delta)\,\overline{b} - \underline{c}$ is small since, in this case, it is more likely that P_t conserves even without the transfer. In that event, k leads to less additional conservation.

Time Inconsistency.—So far, we have assumed, for simplicity, that D decides on a time-invariant k. In that case, D takes advantage of the multiplier by committing to a large k, since k_τ at time $\tau > t$ is decreasing not only x_τ, but also x_t because of the domino effect.

If P_t could commit to k_0^* for time t and k_+^* for later periods, he would prefer $k_0^* \leq k^*$ and $k_+^* \geq k^*$, where k^* is given by (12). However, this plan is not renegotiation proof: In period $t+1$, D would prefer $k_0^* \leq k^*$ rather than $k_+^* \geq k^*$, and so on.[21]

Suppose now that D can commit to k_t only, at the beginning of period t, before observing θ_t,[22] and that she cannot affect actual or expected future compensation levels (as in an MPE). Any positive effect of k_t on earlier x's is sunk, making it less beneficial for D to raise k as much as D preferred when D decided on a time-invariant k. Consequently, the MPE k_t, call it k^M, is smaller than k^*.

Proposition 4. *Suppose $\theta_k'\left(x^M\right) > 0$ and that D, at the beginning of period t, can commit only to k_t. There is an equilibrium in which D pays $k^M \leq k^*$ if P_t conserves, where:*

$$k^M = \max\left\{0, k^* - \frac{\left(1 - x^M\right)\theta_k'}{2}\right\} \leq k^*.$$

For simplicity, and to facilitate a comparison, k^M is defined relative to k^*.[23] The result is then intuitive: The reason D would like to commit to a large k^* is that less exploitation in the future influences x_t. The larger this influence is (i.e., the larger $\theta_k' \equiv \partial\theta_k\left(x^M\right)/\partial x^M = \delta\left(p\Delta - k^M\right)$ is), the larger the difference between k^* and k^M is.[24]

If $x \uparrow 1$, $k \uparrow d$ regardless of whether D commits or not, so then the difference $k^* - k^M$ vanishes. (See Observation 2 in the Appendix.)

As shown in the Appendix, the optimal k^M depends on the expected k in the future, so there can be multiple equilibria. There can be an equilibrium with $k^M = 0$, in addition to the one described by Proposition 4. Intuitively, it may be too expensive to persuade P_t to conserve if P_t expects no future payments and thus a large x.

Corollary 3. *The different k_t's are strategic complements: If $k = k^* - \left(1 - x^M\right)\theta_k'/2 > 0$ in later periods, the same k is optimal in this period. If $k = 0$ in later periods, $k = 0$ may be optimal in this period.*

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[21] It is generally optimal with backloaded payments in dynamic principal-agent problems (Ray, 2002). However, as in Acemoglu et al. (2008), the scopes for backloading are limited here because the agent is short lived (i.e., P_t does not care directly about the benefits to later principals).

[22] If D observes θ_t before deciding on k_t, the equilibrium k_t is qualitatively similar but it must be derived from a cubic expression instead of from a quadratic expression.

[23] An explicit equation for k^M is derived in the Appendix.

[24] If k^M is so large that $\theta_k' = \delta\left(p\Delta - k^M\right) < 0$, then the president at time t considers future presidents to be paid to conserve too much. In this case, a smaller x increases x_t, and D would like to commit to a smaller future k. This possibility is discussed in Section 5.

3.2. *Lobbying for Exploitation*

Just as there may exist a stakeholder willing to pay for conservation, there may exist another stakeholder willing to pay for exploitation. In particular, agricultural sectors are often lobbying to get access to new land. It is reasonable to assume that their lobbying expenditures can persuade and benefit a president caving in to these requests.

Effects of Lobbying.—If a lobby contribution l is paid conditional on exploitation and only in period t, the effect of l on x_t is exactly as in (4) if k in (9) is replaced by $-l$. This is intuitive, since l is a payment for the opposite of k.

If l will be paid to the president in any period in which a president exploits the resource, then $x_t = x$ will be given by (10), as before, if just k is replaced by $-l$. Even though $x_t(x)$ is linear in l, x is convex in l. Once again, the multiplier is at play: When P_t anticipates that future lobbying will raise x, then P_t becomes more willing to exploit at time t because of the reduced future x as well as because of the possibility to obtain l right now. In other words, the presence (and anticipation) of future lobbying helps the lobby obtain what it seeks today (i.e., exploitation) at a lower cost.

Optimal Lobbying.—Suppose the (activist/agricultural) lobby group, A, is long-lived (the next section permits the lobby group to be less than long-lived). If A's present-discounted value of succeeding with exploitation is represented by a (for "agricultural value"), and A pays l to the president as soon as he exploits, A's continuation value is:

$$V^A = x(a-l) + (1-x)\delta V^A = \frac{x(a-l)}{1-\delta(1-x)}. \tag{13}$$

When we substitute for x and take the derivative w.r.t. l, we find A's optimal l.

Proposition 5. *The optimal l, from A's point of view, is:*

$$l^* \equiv \arg\max_l V^A = \max\left\{0, \frac{1}{2}\left[a - \frac{\sigma}{1-\delta}\frac{\underline{x}}{\overline{x}-\underline{x}} - \overline{b} + \frac{\underline{c}}{1-\delta}\right]\right\}. \tag{14}$$

Once again, the stakeholder pays more when the stake (here, a) is large and P_t has a lot of discretion (in that $\overline{x} - \underline{x}$ is large). So, the lobby expenditure increases regardless of whether P_t has access to more effective exploitation technology or conservation technology – or if institutions are weak. As long as $\overline{x}$ is large or $\underline{x}$ is small, P_t's decision matters more to A.

However, in contrast to D, A pays less when $\bar{b} - \frac{c}{1-\delta}$ is large because P_t is then quite likely to exploit in any case and l leads to less additional extraction.

Time Inconsistency.—When A decides on its time-invariant payments, A takes advantage of the multiplier by committing to a large l, since l_τ at time $\tau > t$ is increasing not only x_τ, but also x_t because of the domino effect. However, this effect is sunk when A enters period τ. Suppose, therefore, that A decides on every l_t at the beginning of period t. As with k, the MPE l, call it l^M, is smaller than l^*.

Proposition 6. *Suppose A, at the beginning of period t, can commit only to l_t. There is an equilibrium in which A pays $l^M \leq l^*$ if P_t exploits, where:*

$$l^M = \max\left\{0, l^* - \frac{x^M \theta'_k}{2(1-\delta)}\right\} \leq l^*.$$

The effect of θ'_k is just as in Proposition 4, but here $\theta'_k = \delta(p\Delta + l)$ is unambiguously positive. If $x \downarrow 0$, $l \uparrow a$ whether or not A commits, so then the difference $l^* - l^M$ vanishes. (See Observation 4 in the Appendix.)

3.3. *Paying (forever) for Conservation and (once) for Exploitation*

It is easy to see (and the Appendix proves) that when D bids for conservation, and A simultaneously bids for exploitation, then the two optimal best-response functions are interdependent:

$$k^* = \max\left\{0, \frac{1}{2}\left[l + d - \sigma\frac{1-\underline{x}}{\overline{x}-\underline{x}} + \delta p\Delta + (1-\delta)\bar{b} - \underline{c}\right]\right\}, \tag{15}$$

$$l^* = \max\left\{0, \frac{1}{2}\left[k + a - \frac{\sigma}{1-\delta}\frac{\underline{x}}{\overline{x}-\underline{x}} - \bar{b} + \frac{c}{1-\delta}\right]\right\}. \tag{16}$$

Corollary 4. *The optimal compensation for conservation, k^*, increases in the lobby contribution, l.*

So, although the presence of lobbying makes it less likely that P_t will conserve, given any k, lobbying is nevertheless increasing the optimal k. Intuitively, with lobbying, the multiplier is larger (because the conflict between presidents and the opposition is larger) and the payment for conservation is more likely to lead to additional conservation.[25]

Analogously, compensations for conservation increase the necessity to lobby, and the equilibrium lobby contributions increase.

The equilibrium $x_t(x)$ continues to be given by (4) if just (3) is replaced by:

$$\theta_{kl}(x) \equiv \delta p\Delta x + (1-\delta)\,\overline{b} - \underline{c} - (k^* - l^*)\left[1 - \delta(1-x)\right]. \tag{17}$$

If we henceforth assume both k^* and l^* are strictly positive, then the total effect of both payments on x is given by the following result.

Proposition 7. *The equilibrium x decreases in $d - a$:*

$$x^* = \frac{\frac{\sigma \underline{x}}{\overline{x}-\underline{x}} + (1-\delta)\,\overline{b} - \underline{c} - (1-\delta)(k^* - l^*)}{\frac{\sigma}{\overline{x}-\underline{x}} - \delta p\Delta + \delta(k^* - l^*)}, \textit{ where} \tag{18}$$

$$k^* - l^* = \frac{1}{3}\left[d - a - \frac{\sigma}{\overline{x}-\underline{x}}\left(1 - \underline{x}\left(\frac{2-\delta}{1-\delta}\right)\right) + (2-\delta)\,\overline{b} - \underline{c}\left(\frac{2-\delta}{1-\delta}\right) + \delta p\Delta\right].$$

With the Markov-perfect payments, x continues to be given by (18) if just $k^* - l^*$ is replaced by $k^M - l^M$.[26] The change in x is ambiguous: As noted above, l^M is smaller than l^* if x is large, while k^M is smaller than k^* if x is small.

Proposition 8. *Suppose $\theta'_{kl} > 0$. Compared with the case with commitment, both x^M and $l^M - k^M$ are larger if and only if*

$$x^* < \frac{1-\delta}{2-\delta}.$$

Figure 3 illustrates that, in both cases, the equilibrium x inreases in $a - d$.

Inefficiency.—At first, it may appear intuitive that d and a enter symmetrically in $k - l$, and thus in x. However, while a is A's present discounted value when the resource is exploited, and the land is forever accessible to agriculture, d is the *per-period flow* payoff to D from conservation. The present-discounted value of conservation forever is $d/(1-\delta) > d$. With D and A, the criterion for when it is socially optimal to exploit

[25] As shown in the Appendix, the multiplier becomes

$$\frac{x}{x_t(0)} = \frac{1}{1 - \delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)(p\Delta + l - k)}.$$

[26] As shown in the Appendix, k^M and l^M are inter-dependent in a similar way as k^* and l^* are.

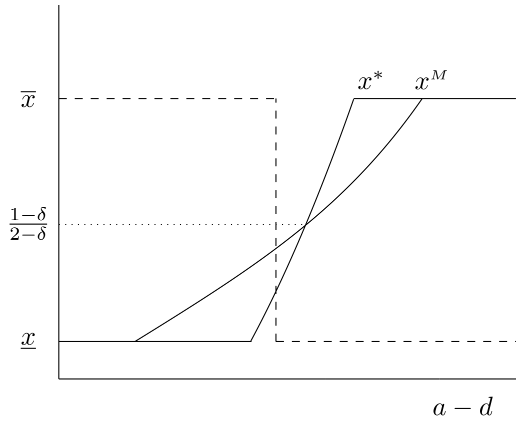

Figure 3: *Equilibrium x increases in $a-d$ whether the stakeholders can commit to the short or the long run.*

changes from (5) to:

$$(1-\delta)(a+b) > c+d. \tag{19}$$

Thus, if $d/a \in (1-\delta, 1)$, the presence of D and A makes conservation more likely to be efficient, but, in equilibrium, their payments increase x. If $d/a \in (1-\delta, 1)$ remains constant when both a and d increase, then $a-d$ increases and the resource will be exploited, even though (19) will eventually fail, i.e., it becomes socially optimal to reduce x, as illustrated by the dashed line in Figure 3.

Corollary 5. *Let a and d increase by the same proportions, so that $d/a \in (1-\delta, 1)$ stays fixed. Eventually, it becomes socially optimal to conserve, but in equilibrium $k-l$ decreases and the resource is exploited with probability one.*

The intuition for this inefficiency is that A needs to pay only one single time for exploitation, while D needs to pay every future P_t for conservation. The future payments, to the later presidents, are costly for D but not fully appreciated by the current president.

This insight suggests that paying the presidents may not necessarily be the best way of achieving conservation. It might be less expensive for D to pay in terms of public goods, or party goods, that increase P_t's conservation value even after P_t retires as president. It may also be more efficient for D to pay A for reducing its lobby effort, than to pay every president in competition with A. These possibilities are investigated in the next section.

4. Cost-Effective Conservation

Paying the president to conserve reduces the conflict between the president and the opposition. With that, the multiplier decreases and so does the effectiveness of another unit of compensation. For that reason, and because of the corollary above, there may be better ways of securing conservation.

It is easy to see that V^D is convex in c. If c increases, x decreases in the future and this raises the benefit of conservation today. Parameter c is exogeneous, but if D funds a public good conditional on conservation, the effect is similar to an increase in c.

In this section, I describe situations in which D is better off by committing to earmark compensations, k_G, for a public good (also benefitting the opposition) or for funds, k_R, administered by the ruling party (benefitting the members of the party), instead of simply paying the president for conservation. In some situations, D can also be better off by paying A to not lobby, instead of competing with A regarding what P_t should do.

To study such targets in a pedagogic setting, it will be assumed that $d - a$ is so large that D conserves in full. This corner solution is relevant also because the value of conserving tropical forests vastly exceeds the benefits of logging, as was argued in the Introduction. So, although Propositions 3–8 restricted attention to interior solutions for x, it is time to pay attention to the corner solution $x = \underline{x}$. (Observation 3 in the Appendix presents the exact condition under which $x = \underline{x}$ is optimal.)

The following discussion will be easier to follow if we allow for full conservation. Thus, let $\underline{x} = 0$.

4.1. *Paying Presidents, Parties, or the Public*

Paying the Public.—If D pays for conservation and this payment is earmarked for a public good, the current president benefits directly from future conservation payments, and not only from the indirect effect through the reduced x. With this, the president is incentivized to conserve more now. On the other hand, paying for public goods is less targeted toward the president, since the funds are tied to goods that may be of secondary importance to the president (with direct transfers to the president, the president can spend the money on public goods, or on private perks, just as the president pleases).

To capture this trade-off, suppose D's per-period payment k_G, conditional on conservation, provides the benefit $\gamma > 0$ per dollar for the opposition as well as for the party in power. It is also reasonable that $\gamma < 1$, since, otherwise, the president (whose value of a dollar is normalized to 1) would prefer to spend his private funds on the public good. Note that γk_G has a role similar to that of the conservation benefit $\underline{c}$, and that the equation for x continues to hold if just $\underline{c}$ is replaced by $\underline{c} + \gamma k_G$.

Paying Parties.—Payments to the president, and earmarks to a public good, are both extreme cases. An intermediate case is that D offers a transfer, k_R, to be administered by the ruling party, so that each dollar gives everyone associated with the ruling party some benefit $\alpha > 0$. It is reasonable that $\alpha > \gamma$, since the party would otherwise prefer to spend all party dollars on the public good. It is also reasonable that $\alpha < 1$, since, otherwise, the president would prefer to transfer his private funds to the party. There are interesting trade-offs if $\alpha \in (\gamma, 1)$ but the results below hold for every α and γ.

In this intermediate case, the current president receives the direct benefit αk_R from conserving today. When it is anticipated that these transfers will arrive also in later periods, the correspondingly lower future x gives the current president an indirect benefit from conserving now. As a third effect, the current president's expected direct benefit of later conservation is $p\alpha k_R$.

With these modifications, the resource is exploited at time t if and only if:

$$\theta_t < \theta_R(x) \equiv \delta p \Delta x + (1-\delta)\bar{b} - \underline{c} - \gamma k_G - \alpha k_R [1 - \delta p (1-x)] - (k-l)[1-\delta(1-x)].$$

To guarantee least-cost conservation, D's problem is:

$$\min_{k \geq 0, k_R \geq 0, k_G \geq 0} (k + k_R + k_G) \text{ s.t. } \theta_R(0) = 0. \tag{20}$$

The solution to D's problem is always a corner solution with payments only to the president, the party, or the public, as illustrated in Figure 4.

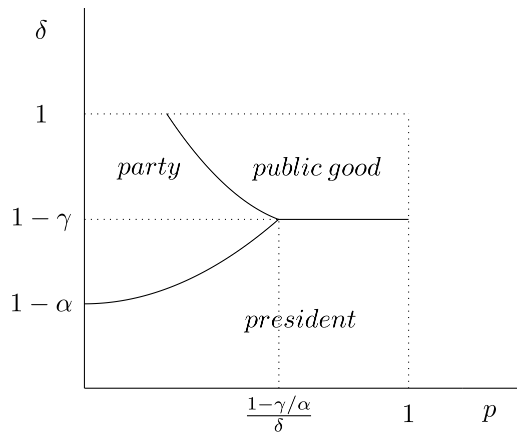

Figure 4: *D benefits from earmarking the funds to public goods if* δ *is large, but from giving the ruling party discretion over the funds if* p *is small.*

Proposition 9. *To ensure maximal conservation (*$x = 0$*), it is optimal for* D *to pay*
(i) the public if δ *is large:*

$$\gamma \geq \max \{1 - \delta, \alpha (1 - \delta p)\}.$$

(ii) the party if p *is small:*

$$\alpha (1 - \delta p) \geq \max \{\gamma, 1 - \delta\},$$

(iii) the president otherwise, i.e., if:

$$1 - \delta > \max \{\gamma, \alpha (1 - \delta p)\},$$

Compensating the public can be best since then P_t benefits directly when future presidents can conserve. This solution is more likely to be best if δ, the weight on future benefits, is large. Allowing the ruling party to spend the money as it pleases is also giving the current P_t direct benefits if his party's future presidents can conserve. This benefit is large only when p, the probability of losing power, is small. Thus, a more stable political environment means that letting parties administer the funds can be best.

The impacts of the valuation parameters α and γ for the comparison are straightforward.

Note that the level of l is irrelevant for this result – the proposition holds for any l – as long as l is the same regardless of how D pays. And, indeed, the equilibrium l is exactly the same regardless of (i)-(iii): When $x \downarrow 0$, A's optimal choice is always $l \uparrow a$, as shown in the Appendix.[27]

It is also easy to check that A would never prefer to direct funds to the party or the public, instead of to the president: Such payments are not only less effective right now (given that $\alpha < 1$ and $\gamma < 1$), but they also increase P_t's value of postponing exploitation, making immediate exploitation less likely.

4.2. *Paying the Lobby*

Compensating short-lived presidents is expensive because D must compensate every one of them for not exploiting a resource. If the lobby group is long-lived, then it can be less expensive to pay A to not lobby, since A anticipates that it can lobby or receive compensations also next period.

Let $q \in [0, 1]$ measure the probability that A will *not* be the relevant lobby group in any future period. (This will not change the previous result.) With probability $1 - q$, the current lobby group can lobby in order to obtain a also in later periods. To treat A and D more or less symmetrically, the reader is free to restrict attention to $q = 0$, as has been done so far. Alternatively, the lobby group and the party in power will be more similar if $q = p$. If $q < p$, the lobby group is more likely to be a player in the future than is the political party in power.

As above, if $x \downarrow 0$, then l increases toward A's value of exploitation, which is a when D does not pay A. If D pays $k_A \geq 0$ to discourage A from lobbying, then A's value of exploitation is reduced because A will subsequently lose the payments from D. The reduced value means that A finds it optimal to reduce l, even if we assume that l is unobservable for D, so that D can condition her payments to A only on whether the resource is exploited and not on the level of l.[28]

[27] It is assumed that A does not significantly benefit directly from any of the transfers k, k_R, or k_G, even though k_G is referred to as a public good. After all, the value of land, a, is likely to be much larger.

[28] In principle, we can here proceed by making one of the following alternative assumptions:

(a) We may assume that D can observe l so that, if A selects $l > 0$ in this period, A does not receive

If D pays the relevant lobby group an amount $k_A \geq 0$ in every period with conservation, A's net value of exploitation is reduced from a to $a - \frac{k_A}{1-\delta(1-q)}$, given the present-discounted value of the per-period k_A. When $x = 0$, the optimal l is also reduced by this amount (regardless of whether A can commit). When this term is substituted in the expression for $\theta_R(0)$ (replacing a), and D solves $\min(k + k_R + k_G + k_A)$ s.t. $\theta_R(0) = 0$, we can see that it is optimal with either $k_A = 0$ or

$$k_A = a[1 - \delta(1-q)], \tag{21}$$

so that A, in that case, prefers $l = 0$. This exercise also leads to the next proposition.

Proposition 10. *D benefits from paying L to not lobby if q is small and p large. The following three cases correspond to the cases in Proposition 9:*

(i) If D compensates the public for conservation, D benefits from paying A to not lobby if:

$$q < (1-\delta)\frac{1-\gamma}{\gamma\delta}.$$

(ii) If D pays the party to conserve, D benefits from paying A to not lobby if:

$$q < (1-\delta)\frac{1-(1-\delta p)\alpha}{(1-\delta p)\alpha\delta}.$$

(iii) If D pays the president to conserve, D always benefits from paying A to not lobby, and strictly so if $q < 1$.

It is quite intuitive that D prefers to pay A when q is small and p is large. If q is small, A appreciates not only the current compensation from D, but also the expected payments in the future. In this case, the per-period payment k_A is effective in persuading A to not lobby. If p is small, P_t appreciates future payments to the party, so then k_R may

k_A in this period and, with probability x, A receives a and the game ends.

(b) D may be unable to observe l. Thus, if the resource is not exploited, A receives k_A and the game continues. If the resource is exploited, then A receives a instead of the flow of k_A every period.

(c) A might, with some chance, learn θ_t before A decides to lobby so as to receive a. As in case (b), the consequence for A is that A loses the flow of k_A every period if and only if P_t exploits. (In this case, it will not matter whether D observes l.)

I have decided to focus on case (b) because (i) it leads to the same outcome as case (c), (ii) this outcome is simpler to describe than the outcome in (a), (iii) the payment following (b) and (c) is larger than under (a) and thus it is robust and sufficient regardless of whether A observes θ_t, or D observes l, and (iv) if D benefits from paying A in cases (b) and (c), then she also benefits from this payment in case (a) (since the payments are then less).

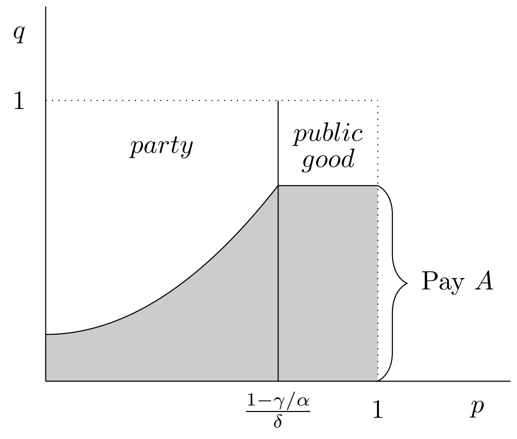

Figure 5: *D benefits from paying L to abstain from lobbying if q is small while p is large.*

reduce x more than k_A can, especially if q is large. Parts (i) and (ii) of the proposition are illustrated in Figure 5. (In the figure, it is assumed that $1 - \delta < \gamma$, so that it is not optimal to pay the president directly.)[29]

Time Inconsistency.—Note that D must commit or build a reputation for earmarking the payments to the public or the party. Although paying parties or the public takes greater advantage of the multiplier, a direct transfer is more efficient right now, when $\alpha < 1$ and $\gamma < 1$. So, at the start of any given period, D's temptation and MPE strategy is always to pay the president directly. In line with Proposition 10(iidi), D can then benefit from paying A to not lobby.

5. Extensions: Alternative Assumptions and Applications

5.1. *Optimal Conservation Targets under Budget Constraints*

Drawing on Section 4.1., we can also show how the optimal target for the conservation funds depends on D's budget and preferences (i.e, on d). Assume, for simplicity, that

[29] Since the claims in Proposition 10 takes the following form: "If D pays...[then]...D always benefits from paying A...", it follows that Proposition 10 is relevant if and only if $k_A = a\left[1 - \delta\left(1 - q\right)\right]$ is insufficient to ensure that $\theta_a\left(0\right) = 0$. In addition, the following is true: For each of the cases in Proposition 10, if $k_A < a\left[1 - \delta\left(1 - q\right)\right]$ is sufficient to ensure that $\theta_a\left(0\right) = 0$, then D compensates A, exclusively.

$l = 0$. The donor's continuation value is:

$$(d - K)\,\frac{1-x}{1-\delta\,(1-x)}, \text{ where}$$
$$K = k + k_G + k_R.$$

It is easy to see that the second term $(\frac{1-x}{1-\delta(1-x)})$ is linear in k. (It was for that reason the expression for the optimal k was so simple to derive.) It is also easy to see that this second term is convex in k_G, and also in k_R if $p < 1$. Intuitively, the additional direct future conservation value associated with funding public goods, or party perks, makes it especially attractive for the president to conserve, particularly if also future conservation is likely (because the funds are large). This is the intuition for why a large budget, K, makes it more likely that it is optimal for D to earmark funds for party perks rather than letting the president decide, and for why it is more likely that D benefits from earmarking the funds for the public goods.

Proposition 11. *If K is D's fixed budget, there exists thresholds K_1, K_2, and K_3, such that:*
(i) D prefers to earmark the funds for the party, rather than letting the president have full discretion, if $K > K_1$,
(ii) D prefers to earmark the funds for the public, rather than letting the president have full discretion, if $K > K_2$,
(iii) D prefers to earmark the funds for the public, rather than the party, if $K > K_3$.

When the budget K is optimally set by the donor, it is likely that a larger d makes it optimal to have a larger budget. It then follows that:

Corollary 6. *There exists thresholds d_1, d_2, and d_3, such that:*
(i) D prefers to earmark the funds for the public, rather than the party, if $d > d_1$,
(ii) D prefers to earmark the funds for the public, rather than letting the president have full discretion, if $d > d_2$,
(iii) D prefers to earmark the funds for the party, rather than letting the president have full discretion, if $d > d_3$.

So, if the donor is formed by a large coalition of countries, d is likely to be large and thus it is likely that the funds should be earmarked to public goods. Of course, as noted above, this requires D to build a reputation for earmarking the funds in this way. (At every time t, it is tempting for D to instead pay the president directly if $\alpha < 1$ and $\gamma < 1$.)

5.2. *Heterogeneous Parties and Elections*

Suppose there are two parties, A and B, and that A is more likely to win as long as the resource exists (i.e., $p^A < p^B$). Suppose there are no office rents (I will relax this assumption below).

Proposition 12. *The minority party exploits the most when it is in power (iff $\Delta > 0$):*

$$x^i = \frac{\left[\underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left(1 + \frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^i\right)\right]\left[(1-\delta)\,\overline{b} - \underline{c}\right]}{1 - \left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2 p^i p^j}, \; i \in \{A, B\} \Rightarrow$$

$$x^B - x^A = \left(p^B - p^A\right)\Delta\frac{\delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^2\left[(1-\delta)\,\overline{b} - \underline{c}\right]}{1 - \left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2 p^A p^B} \Rightarrow$$

$$x^B > x^A \text{ iff } p^B > p^A.$$

It also follows from this equation (see the Appendix) that less is exploited when the probability that the major party wins increases.

Proposition 13. *Expected exploitation is maximized when $p^i \to 1/2$ (iff $\Delta > 0$):*

$$\left(1-p^i\right)x^i + p^i x^j = \frac{\left[\underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left(1 + 2\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\left(1-p^i\right)p^i\right)\right]\left[(1-\delta)\,\overline{b} - \underline{c}\right]}{1 - \left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2\left(1-p^i\right)p^i}.$$

Elections.—We can easily endogenize the winning probabilities. Suppose that the median voter prefers conservation ($(1-\delta)\,b < c$) and elects party i if the difference in continuation value, $V_i^m - V_j^m$, is larger than the popularity shock favoring party j and suppose this shock is i.i.d. uniformly and symmetrically distributed over time. Then, party i is more likely to win if $V_i^m - V_j^m$ is large, which holds if $x^j - x^i$ is large. Since $x^j > x^i$ if $p^j > p^i$, there can be multiple equilibria where a party receives less votes because the party exploits more, and the party exploits more because it is less likely to be in power later.

Proposition 14. *There are multiple equilibria where* $p^i > p^j$ *and* $x^i > x^j$*,* $i \in \{A, B\}$*. In equilibrium, the asymmetry* $|p^i - p^j|$ *increases in* $\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta$*:*

$$\left(1-p^i\right)p^i = \frac{1-2\delta\Delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^2\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2}$$

Office rents.—Now, suppose R measures the rents for being in office, per se. Suppose, further, than if the resource is fully exploited, then $p^i = 1/2$, since then there is no longer any disagreement between the parties when it comes to this issue. If $p^B > 1/2$, party B faces an additional incentive to exploit: Not only will one then obtain the benefit b_P, but in addition the chance for office rents will be larger in the future. This effect is naturally strengthening B's incentive to exploit. For the analogous reason, A's incentive to exploit decreases (iff $\Delta > 0$), since A loses his electoral advantage once the resource is exploited.

Proposition 15. *Consider an equilibrium with* $p^B > p^A$ *and* $x^B > x^A$*. If the office rent* R *increases,* x^B *increases and* x^A *decreases, so polarization increases. As a consequence,* p^B *increases and* p^A *decreases.*

5.3. *Postponing Reforms* ($\Delta < 0$)

The above framework can shed light on several other situations besides resource extraction. As discussed in the Introduction, a larger body of literature analyzes macroeconomic policies in dynamic contexts. In some of these papers, the decision is whether to cut spending and stabilize debt (Alesina and Drazen, 1991) or to invest in state capacity (Besley and Persson, 2009; 2010). Stopping the game in this way is costly for a policymaker, and every government may hope that this cost will instead be paid by subsequent governments.

This situation fits the model except that now it is reasonable that $\Delta < 0$. The above equations hold also for this case, but the interpretations of the results will be different. When $\Delta < 0$, each president is more likely to stop the game (by completing the project of stabilizing debt, for example) if later governments are *less* likely to stop the game in this way. That is, $\partial\theta(x)/\partial x < 0$, and the multiplier is thus less than 1. This sign also eliminates the possibility of multiple equilibria, described by Proposition 2(i-2).[30]

Also for this application, it seems reasonable that stakeholders (domestic businesses) may lobby the president to postpone the action, while external stakeholders (such as the IMF) may try to persuade the government to act (and repay the debt). The above analyses of such payments continue to hold, but the differences between the long-term optimal payments (k^* and l^*) and the short-term (Markov-perfect) payments (k^M and l^M) change sign.

Corollary 7. *When $\partial\theta(x)/\partial x < 0$, the multiplier is less than 1 and both A and D prefer to commit to lower levels of future payments.*

For the donor (e.g., the IMF), the intuition is that it is beneficial to reduce the probability that future governments will act, so as to prompt the current government to act, instead. When the future arrives and no debt is repaid, however, the IMF is inclined to continue the effort by helping the government to repay the debt (this is the classic soft budget constraint).

The results from the previous subsection are also modified in interesting ways when $\Delta < 0$. In this case, each party hopes the other party ends the game, since that is costly. It is natural to assume, now, that the voters prefer to end the game (by completing the reform).

Corollary 8. *When $\Delta < 0$, the minor party B is less likely to act (by "completing a reform"). There are multiple equilibria in which $x^B < x^A$ and $p^B > p^A$ even though the parties are identical in other respects. If the office rent R increases, the two policies converge: x^B increases and x^A decreases.*

The intuition for the last statement is that because the issue gives A an electoral advantage (because A is more likely to end then game than B), then A's incentive to complete the project is weakened but B's is strengthened (as in Powell, 2019).

[30] The conjectures discussed in Section 2.5 are also reversed: If $\Delta < 0$, the dominant party is more likely to end the game. When also the voters prefer to end the game, high office rents can motivate the minority party to adopt the opponent's policy (of ending the game), and vice versa (as in Powell, 2019), in order to eliminate its handicap in the election.

5.4. *Convex Extraction Costs and Price Shocks: Interior Solutions*

In this extension, I will show that quadratic extraction costs in the gradual-extraction model is isomorphic to a model with a uniformly distributed price on the part of the resource that is extracted. (I.e., this part generalizes the reasoning in Section 2.2.)

A Model with Stochastic Resource Prices.—Suppose c is the same for everyone, but that from b is substracted a benefit-reduction ϵ_t, measuring a negative shock on the profit from logging (due to, for example, low resource prices in period t). Let ϵ_t be uniformly i.i.d. on $[0, \sigma_b]$. As before $b_p - b = \Delta$ is the additional benefit from exploitation for the party in power.

Let $V^P(x)$ be the continuation value in the future if the resource is conserved now. Anticipating $V^P(x)$, the president exploits if:

$$b_P - \epsilon_t > c + \delta V^P(x) \Rightarrow$$
$$\epsilon_t < \widehat{\epsilon} \equiv b_P - c - \delta V^P(x),$$

which holds with probability:

$$x_t^* = \Pr(\epsilon_t < \widehat{\epsilon}) = \frac{\widehat{\epsilon}}{\sigma_b} = \frac{1}{\sigma_b}\left[b_P - c - \delta V^P(x)\right]. \tag{22}$$

Given this threshold, we have that $\mathrm{E}(b_P - \epsilon_t \mid \epsilon_t < \widehat{\epsilon}) = b_P - \widehat{\epsilon}/2 = b_P - \sigma_b x/2$. Anticipating this, and with $\widetilde{b} \equiv b + (1-p)\Delta$, we have:

$$V^P(x) = \left(\widetilde{b} - \sigma_b x/2\right)x + (1-x)\left(c + \delta V^P\right) = \frac{\left(\widetilde{b} - \sigma_b x/2\right)x + (1-x)c}{1 - \delta(1-x)}. \tag{23}$$

Substituted into (22), we get

$$x_t = \frac{1}{\sigma_b}\left[b_P - c - \delta\frac{\left(\widetilde{b} - \sigma_b x/2\right)x + (1-x)c}{1-\delta(1-x)}\right].$$

A Model with Gradual Extraction and Convex Extraction Costs.—Suppose now that there are no shocks, but that x is the fraction of the resource that is extracted. The remaining stock of the resource next period is $S_{t+1} = (1 - x_t) S_t$, as in Section 2.2. Suppose, further, that the extraction cost is $\sigma_b S_t x_t^2/2$, given some parameter $\sigma_b > 0$. This cost function means that the marginal extraction costs increases in the fraction that is extracted. It is natural that, given x_t, the total cost may be proportional to S_t. With this, the continuation value per unit of the stock is exactly as in (23), and, anticipating V^P, the optimal extraction level is

$$x_t^* = \arg\max_{x_t} \left(b_p x_t S_t - \sigma_b \frac{x_t^2}{2} S_t + (1 - x_t) S_t \left(c + \delta V^P (x) \right) \right) = \frac{1}{\sigma_b} \left[b_P - c - V^P (x) \right],$$

exactly as in (22).

Proposition 16. *The stochastic-price model and the convex-extraction-cost model are isomorphic:*
(i) The per-unit-of-stock continuation value is the same for both models.
(ii) The optimal x *is the same for both models.*
(iii) The assumption of uniformly distributed shock is analogous to the assumption of a quadratic extraction cost.

Heterogeneous Parties.—This model generalizes the basic model, which restricted attention to a constant Δ (which had to be either positive or negative). Here, the optimal x is interior and thus x is perceived to be too small if x is small (as when $\Delta < 0$) and too large if x is large (as when $\Delta > 0$). In either case, $V^P (x)$ is less than it is at the optimal x.

It follows that if there are two parties with different preferences, then each party $i \in \{A, B\}$ extracts more when $p^i > 0$ than when $p^i = 0$, even if $b_P = b$.

To see this, note that if we henceforth assume $b_P = b$, but that parties have different b_i's and c_i's, then party i's optimal x is (under commitment or with $p^i = 0$):

$$x^{i*} = \arg\max V_i^P = \frac{b_i - c_i}{\sigma_b}.$$

Thus, for any expected future $x \neq x^{i*}$, the continuation value is lower, $V_i^P (x) < V_i^P (x^{i*})$, and then (22) implies that i prefers $x_t > x^{i*}$ at any time t he is in power.

Proposition 17. *Suppose that parties prefer different* x*'s but preferences are the same whether the president's party is in vs. out of office (i.e.,* $b_{P,i} = b_i$*). Then, each party* $i \in \{A, B\}$ *makes decisions s.t.*

$$x^i > x^{i*} \textit{ iff } p^i > 0.$$

That is, both parties extract more when they fear to lose power – not because it is more beneficial to extract in office – but because each party perceives the resource to be mismanaged by the other party (whether that party is perceived to extract too much or too little), and thus it is less attractive to conserve the resource.

Now, suppose B is the party preferring the largest x: $x^{B*} > x^{A*}$. If D pays A to conserve more, V_B^P declines and (22) implies that x^B increases. In other words, payments (to A) in return for conservation can be counter-productive (since B may extract more).

On the other hand, if D pays B marginally to conserve, both x^B and x^A declines (x^A declines because V^A increases). This mechanism suggests that it may be less risky to pay B to conserve than paying A.

Corollary 9. *Suppose $x^{B*} > x^{A*}$. (i) If D pays A to conserve, x^B may increase. (ii) If D pays B (marginally) to conserve, both x^B and x^A are reduced.*

5.5. *Alternative Equilibria*

Above, the set of MPEs for the gradual-extraction model coincides with the set of SPEs for the probabilistic exploitation model (if only the outcome could be conserved). This claim holds also for the alternative model in Section 5.4. However, when x represents gradual extraction (as a fraction of the stock) and S_t is the size of the remaining stock, then there are other SPEs in addition to the MPEs emphasized above.

As in other dynamic games with an infinite time horizon, there can be a large set of SPEs when the discount factor is large. For example, in the basic model, there may be an SPE in which every president sets $x_t = \underline{x}$ but, as soon as one president has deviated from this strategy, then we (re)turn to the MPE described in Section 2.4. It is easy to check that these strategies, and the outcome $\underline{x}$, can constitute an SPE if δ is above some threshold. If δ is lower than that threshold, then $x_t = \underline{x}$ cannot be guaranteed unless D makes $x_t = \underline{x}$ more attractive by compensating for conservation.

Formally, suppose V_E^P is the continuation value for the least conservation-friendly type in the cooperative equilibrium with low exploitation:

$$V_E^P = \widetilde{b}\frac{\underline{x}}{1-\delta(1-\underline{x})} + \underline{c}\frac{1-\underline{x}}{1-\delta(1-\underline{x})},$$

where $\widetilde{b} \equiv pb + (1-p)\,\overline{b}$, and let V_M^P be the same type's continuation value in the MPE:

$$V_M^P = \widetilde{b}\frac{x}{1-\delta(1-x)} + \underline{c}\frac{1-x}{1-\delta(1-x)} = \frac{\left(\widetilde{b}-\underline{c}\right)\left[\overline{b}-\frac{c}{1-\delta}\right] + \underline{c}\left[\frac{\widetilde{\sigma}-\delta p\Delta}{1-\delta}\right]}{\widetilde{\sigma}+\delta\left[\overline{b}-\frac{c}{(1-\delta)}\right]-\delta p\Delta}.$$

For $x = \underline{x}$ always to be an equilibrium, it must be attractive with $x = \underline{x}$ even for the least conservation-friendly president:

$$k + \underline{x}\overline{b} + (1-\underline{x})\left(\underline{c}+\delta V_E^P\right) \geq \overline{x}\overline{b} + (1-\overline{x})\left(\underline{c}+\delta V_M^P\right),$$

which holds iff k is sufficiently large.[31]

Proposition 18. *When $x \in [\underline{x}, \overline{x}]$ represents gradual extraction, there exists an SPE outcome that guarantees $x_t = \underline{x}\forall t$, even if $k = 0$, iff $\delta \geq \overline{\delta}$. If δ falls below $\overline{\delta}$, $k > 0$ is necessary to sustain $x_t = \underline{x}\forall t$ as an SPE.*

However, note that if $\overline{x} = 1$, the condition becomes:

$$k + \underline{x}\overline{b} + (1-\underline{x})\left(\underline{c}+\delta\left[\widetilde{b}\frac{\underline{x}}{1-\delta(1-\underline{x})} + \underline{c}\frac{1-\underline{x}}{1-\delta(1-\underline{x})}\right]\right) \geq \overline{b},$$

but, when this inequality holds for some k, then $x = \underline{x}$ is also an MPE outcome for that same k. Thus, when $x = \underline{x}$, SPEs do not permit better equilibria than MPEs do.

6. Concluding Remarks

This paper provides a framework for analyzing the game between consecutive governments when each of them decides whether to exploit or conserve a resource, such as a tropical forest. If a future government is more likely to exploit the resource, the current government becomes more likely to exploit, as well. The exploitation multiplier means that the outcome can be very sensitive to small changes in the parameters and to expectations regarding future policies. A lobby group, eager to exploit, can benefit from the multiplier. A donor, interested in conservation, can also take advantage of the mirroring

[31] Here, the role of k is to make a stream of environmentally friendly decisions self-enforcing, just like environmentally friendly technology made the climate agreement self-enforcing in the analysis by Harstad et al. (2019).

conservation multiplier, but there is an asymmetry between paying once for exploitation vs. forever for conservation.

On the one hand, the results provide an explanation of recent developments in Brazil: Although earlier governments have succeeded in reducing deforestation, the current government facilitates deforestation. The current government is unlikely to stay in power in the future (given its sagging popularity and historically bad polls), so it is in line with the model that it prefers exploitation rather than conservation. The prospects of new international trade agreements, signed with the EU, US, and EFTA, make it plausible that deforestation will eventually occur, in any case. Anticipating all this, the government benefits from permitting deforestation already now.

On the other hand, the results provide a number of normative policy implications. First, payments contingent on conservation (i.e., REDD+) can have dramatically large effects because of the multiplier, but only when the payments are large enough to counterbalance the effect of the lobby contributions. Second, the anticipation of future payments, and the trust that they will continue to be offered, may have larger effects than the contemporary effects of current payments. It is thus essential to build credibility that payments will continue. Third, it is tempting for the donor to offer funds that can be used at the discretion of the president, but it may be more effective to build a reputation for earmarking the funds for public goods, beneficial also for parties no longer in power. Finally, if the lobby group, willing to pay for exploitation, is more of a long-run player than is the current political party in power, then cost-effective conservation requires the donor to compensate the lobby for halting its lobbying effort.

Appendix

Notation: To faciliate the later proofs, all proofs allow for a payment k to P_t if P_t conserves, and a payment l when he exploits, as discussed in Section 3. Furthermore: I will permit the value of conservation in the future to be different for P_t when P_t's party is in power, than when he is not in power. In particular, P_t's value of conservation whenever P_t's party is not in power is $c_P = \underline{c} + \theta_t$, while P_t's value of conservation is $\widehat{c}_P$ whenever P_t's party is in power, where $\widehat{c}_P = \widehat{c} + \theta_t$, $\widehat{c} = \underline{c} + f$, and f can be positive or negative. Propositions 1 and 2 (and their proofs) follow by requiring $k = l = f = \widehat{c} - \underline{c} = 0$. I also use the simplification $\widetilde{\sigma} \equiv \frac{\sigma}{\overline{x} - \underline{x}}$ and $m \equiv k - l$.

Proof of Proposition 1:
P_t receives $\overline{b}$ if he cuts now. Suppose that if P_t does not cut now, then his party will cut with probability y any later period it is in power, while the opposition exploits with probability x any period P_t's party is not in power. With this, the current P_t's continuation value at the beginning of any *later* period, $\tau > t$, is:

$$\begin{aligned}
V^P &= (1-p)\, y\overline{b} + pxb + (1-p)(1-y)\left(\widehat{c}_P + \delta V^P\right) + p(1-x)\left(c_P + \delta V^P\right) \\
&= \frac{(1-p)\, y\overline{b} + pxb + (1-p)(1-y)\,\widehat{c}_P + p(1-x)\, c_P}{1 - \delta(1-p)(1-y) - \delta p(1-x)}.
\end{aligned}$$

The numerator as well as the denominator are clearly positive. Therefore, P_t prefers to cut now if:

$$\begin{gathered}
k + \widehat{c}_P + \delta V^P < \overline{b} + l \Leftrightarrow \\
k + \widehat{c}_P + \delta \frac{(1-p)\, y\overline{b} + pxb + (1-p)(1-y)\,\widehat{c}_P + p(1-x)\, c_P}{1 - \delta(1-p)(1-y) - \delta p(1-x)} < \overline{b} + l \Leftrightarrow \\
(1-p)\, y\overline{b} + pxb + (1-p)(1-y)(\widehat{c} + \theta_t) + p(1-x)(\underline{c} + \theta_t) < \\
\frac{1}{\delta}\left(\overline{b} + l - k - \widehat{c} - \theta_t\right)\left[1 - \delta(1-p)(1-y) - \delta p(1-x)\right] \Leftrightarrow
\end{gathered}$$

$$\begin{aligned}
\theta_t &< \left(\overline{b} + l - k - \widehat{c}\right)\left[1 - \delta(1-p)(1-y) - \delta p(1-x)\right] \\
&\quad - \delta\left[(1-p)\, y\overline{b} + pxb + (1-p)(1-y)\,\widehat{c} + p(1-x)\,\underline{c}\right] \\
&= (1-\delta)\,\overline{b} + \delta p\left(\overline{b} - b\right) x - \widehat{c} + \delta p(1-x)(\widehat{c} - \underline{c}) \\
&\quad + (l-k)\left[1 - \delta(1-p)(1-y) - \delta p(1-x)\right] \Leftrightarrow \\
\theta_t &< \theta(x) \equiv (1-\delta)\,\overline{b} - \widehat{c} + \delta p \Delta x + \delta p(1-x) f \\
&\quad + (l-k)\left[1 - \delta(1-p)(1-y) - \delta p(1-x)\right].
\end{aligned}$$

Observation 1: If $l = k$, $\theta(x)$ depends on x, but not on y.

So, when there is neither lobbying nor donations, then the level of y is not relevant for P_t's decision. This is natural, since if P_t is indifferent now, he is indifferent later, and thus to the level of y, as well.

Even if we do not impose $l = k$, $\theta(x)$ simplifies to the following when $y = x$:

$$\theta(x) = (1-\delta)\,\overline{b} - \widehat{c} + \delta p \Delta x + \delta p (1-x) f + (l-k)\left[1 - \delta(1-x)\right], \tag{24}$$

which, in turn, simplifies to (4) when $f = l - k = 0$.

The probability that P_t *prefers* to exploit is:

$$\begin{gathered} 0 \text{ if } \theta(x) \leq 0, \\ \theta(x)/\sigma \text{ if } \theta(x) \in [0, \sigma], \\ 1 \text{ if } \theta(x) \geq \sigma. \end{gathered}$$

If P_t prefers to (not) exploit, he exploits with probability $\overline{x}$ ($\underline{x}$). Thus, the probability for exploitation is

$$x_t(x) = \overline{x} \cdot \frac{\theta(x)}{\sigma} + \underline{x} \cdot \left(1 - \frac{\theta(x)}{\sigma}\right) = \underline{x} + (\overline{x} - \underline{x}) \cdot \frac{\theta(x)}{\sigma}, \tag{25}$$

if $\theta(x) \in [0, \sigma]$, while $x_t(x) = \underline{x}$ if $\theta(x) < 0$ and $x_t(x) = \overline{x}$ if $\theta(x) > \sigma$. This can be written as (4). *QED*

Proof of Proposition 2:
The first three cases are trivial, but (A1) and (A2) are, respectively, more generally written as:

$$\begin{aligned} \theta(\underline{x})/\sigma > \underline{x} &\Leftrightarrow (1-\delta)\,\overline{b} - \widehat{c} + \delta p (1-\underline{x}) f + (l-k)\left[1 - \delta(1-\underline{x})\right] > \underline{x}(\sigma - \delta p \Delta), \\ \theta(\overline{x})/\sigma < \overline{x} &\Leftrightarrow (1-\delta)\,\overline{b} - \widehat{c} + \delta p (1-\overline{x}) f + (l-k)\left[1 - \delta(1-\overline{x})\right] < \overline{x}(\sigma - \delta p \Delta). \end{aligned}$$

When both hold (case ii-2), there exists, by continuity, $x \in [\underline{x}, \overline{x}]$ such that $x_t(x) = x$. To find this fixed point, substitute in for $\theta(x)$ and $x_t(x) = y = x$ in (25) and solve for x to obtain:

$$x = \frac{\widetilde{\sigma}\underline{x} + (1-\delta)\,\overline{b} - \underline{c} - f(1-\delta p) + (1-\delta)(l-k)}{\widetilde{\sigma} - \delta p (\Delta - f) - \delta(l-k)}. \tag{26}$$

With $f = l - k = 0$, we arrive at (6). *QED*

Proof of the second-derivatives at the end of Section 2:
From (25):

$$\frac{\partial x}{\partial \underline{x}} = 1 - \frac{\theta(x)}{\sigma} + \frac{\overline{x} - \underline{x}}{\sigma} \left(\delta p \left(\Delta - f \right) + \delta \left(l - k \right) \right) \frac{\partial x}{\partial \underline{x}}$$

$$= \frac{1 - \frac{\theta(x)}{\sigma}}{1 - \frac{\overline{x} - \underline{x}}{\sigma} \left(\delta p \left(\Delta - f \right) + \delta \left(l - k \right) \right)}, \text{ so}$$

$$\frac{\partial^2 x}{\left(\partial \underline{x}\right)^2} < 0, \text{ as } \theta'(x) > 0 \text{ and } x \text{ increases in } \underline{x}.$$

$$\frac{\partial x}{\partial \overline{x}} = \frac{\theta(x)}{\sigma} + \frac{\overline{x} - \underline{x}}{\sigma} \left(\delta p \left(\Delta - f \right) + \delta \left(l - k \right) \right) \frac{\partial x}{\partial \overline{x}}$$

$$= \frac{\frac{\theta(x)}{\sigma}}{1 - \frac{\overline{x} - \underline{x}}{\sigma} \left(\delta p \left(\Delta - f \right) + \delta \left(l - k \right) \right)}, \text{ so}$$

$$\frac{\partial^2 x}{\left(\partial \overline{x}\right)^2} > 0, \text{ as } \theta'(x) > 0 \text{ and } x \text{ increases in } \overline{x}.$$

QED

Proof of Proposition 3:
First, note that, with (26), and with the simplified notation $m \equiv k - l$, the following expression is linear in k:

$$\frac{1-x}{1-\delta(1-x)} = \frac{\widetilde{\sigma}\left(1-\underline{x}\right) - \delta p\left(\Delta - f\right) + \delta m - \left[\left(1-\delta\right)\overline{b} - \widehat{c} + \delta p f - \left(1-\delta\right) m\right]}{\left(1-\delta\right)\left[\widetilde{\sigma} - \delta p\left(\Delta - f\right) + \delta m\right] + \delta\left[\widetilde{\sigma}\underline{x} + \left(1-\delta\right)\overline{b} - \widehat{c} + \delta p f - \left(1-\delta\right) m\right]}$$
$$= \frac{\widetilde{\sigma}\left(1-\underline{x}\right) - \delta p \Delta + k - l - \left(1-\delta\right)\overline{b} + \widehat{c}}{\widetilde{\sigma}\left[1-\delta\left(1-\underline{x}\right)\right] + \delta\left[\left(1-\delta\right)\overline{b} - \widehat{c}\right] - \delta\left(1-\delta\right) p\Delta + \delta p f}.$$

Since this expression is linear in k, it is straightforward to maximize (11) and derive the optimal k, given l. The first-order condition w.r.t. $k \geq 0$ gives (the second-order condition holds trivially):

$$\left(d-k\right)\frac{\partial}{\partial k}\left(\frac{1-x}{1-\delta(1-x)}\right) - \frac{1-x}{1-\delta(1-x)} \leq 0 \Leftrightarrow \tag{27}$$
$$\frac{d-k}{\widetilde{\sigma}\left[1-\delta\left(1-\underline{x}\right)\right] + \delta\left[\left(1-\delta\right)\overline{b} - \widehat{c}\right] - \delta\left(1-\delta\right) p\Delta + \delta p f}$$
$$\leq \frac{\widetilde{\sigma}\left(1-\underline{x}\right) - \delta p \Delta + k - l - \left(1-\delta\right)\overline{b} + \widehat{c}}{\widetilde{\sigma}\left(\left[1-\delta\left(1-\underline{x}\right)\right]\right) + \delta\left[\left(1-\delta\right)\overline{b} - \widehat{c}\right] - \delta p\Delta\left(1-\delta\right) + \delta p f} \Leftrightarrow$$
$$d - k - \left[\widetilde{\sigma}\left(1-\underline{x}\right) - \delta p \Delta + k - l - \left(1-\delta\right)\overline{b} + \widehat{c}\right] \leq 0, \tag{28}$$

with equality if $k > 0$, if the corresponding x is in $(\underline{x}, \overline{x})$. With $\widehat{c} = \underline{c}$ and $l = 0$, we arrive at (12).

Observation 2: If $x \to 1$, (27) requires $k \to d$.

We obtain the corner solution $x = \underline{x}$ if (28) is positive at the k ensuring $\theta_{kl}\left(\underline{x}\right) = 0$.

From (24), we see that this is the k satisfying:

$$\theta_{kl}(\underline{x}) = (1-\delta)\overline{b} - \widehat{c} + \delta p \Delta \underline{x} + \delta p (1-\underline{x}) f + (l-k)[1-\delta(1-\underline{x})] = 0 \Leftrightarrow$$
$$k = l + \frac{1-\delta}{1-\delta(1-\underline{x})}\overline{b} - \frac{\widehat{c}}{1-\delta(1-\underline{x})} + \frac{\delta p \Delta \underline{x}}{1-\delta(1-\underline{x})} + \frac{\delta p (1-\underline{x}) f}{1-\delta(1-\underline{x})}$$

At this k, (28) is indeed positive if $d \geq \overline{d}$, where

$$\overline{d} \equiv l + 2\frac{1-\delta}{1-\delta(1-\underline{x})}\overline{b} - 2\frac{\widehat{c}}{1-\delta(1-\underline{x})} + 2\frac{\delta p \Delta \underline{x}}{1-\delta(1-\underline{x})} + 2\frac{\delta p (1-\underline{x}) f}{1-\delta(1-\underline{x})}$$
$$+ \widetilde{\sigma}(1-\underline{x}) - \delta p \Delta - (1-\delta)\overline{b} + \widehat{c}.$$

Observation 3: When $d \geq \overline{d}$, D pays so much that (A1) fails and $x = \underline{x}$. *QED*

Proof of Proposition 4:
Note that if we fix the future k (and thus the future x), we get:

$$\frac{\partial V_t^D}{\partial k_t} = \frac{\partial(1-x_t)}{\partial k_t}\left(d - k_t + \delta V^D\right) - (1-x_t), \text{ where} \tag{29}$$
$$\frac{\partial(1-x_t)}{\partial k_t} = \frac{\overline{x}-\underline{x}}{\sigma}[1-\delta(1-x)] \text{ and}$$
$$V^D = (d-k)\frac{1-x}{1-\delta(1-x)}.$$

Equalizing (29) to zero gives the f.o.c. (the s.o.c. clearly holds):

$$\frac{\overline{x}-\underline{x}}{\sigma}[1-\delta(1-x)]\left(d-k_t+\delta V^D\right) = 1-x_t \Leftrightarrow \tag{30}$$
$$[1-\delta(1-x)](d-k_t) + \delta(d-k)(1-x) = \widetilde{\sigma}(1-x_t), \tag{31}$$

and, with (25), (31) becomes

$$[1-\delta(1-x)](d-k_t) + \delta(d-k)(1-x)$$
$$= \widetilde{\sigma}\left(1-\underline{x}-\frac{1}{\widetilde{\sigma}}\left[(1-\delta)\overline{b} - \widehat{c} + \delta p \Delta x + \delta p(1-x) f + (l_t - k_t)[1-\delta(1-x)]\right]\right)$$
$$= \widetilde{\sigma}(1-\underline{x}) - \left[(1-\delta)\overline{b} - \widehat{c} + \delta p \Delta x + \delta p(1-x) f + (l_t-k_t)[1-\delta(1-x)]\right] \Leftrightarrow$$

$$(2k_t - d - l_t)[1-\delta(1-x)] \tag{32}$$
$$= \delta(d-k)(1-x) - \left[\widetilde{\sigma}(1-\underline{x}) - (1-\delta)\overline{b} + \widehat{c}\right] + \delta p \Delta x + \delta p (1-x) f.$$

With $\lambda \equiv k_t - k$, and when (28) is substituted into the bracket on the r.h.s. of (32), we can rewrite this expression as follows:

$$\begin{aligned}
&(2k_t - d - l_t)\,[1-\delta(1-x)] \\
&= \delta(d-k)(1-x) - [(d-k^*) - (k^*-l^*) + \delta p\Delta] + \delta p\Delta x + \delta p(1-x) f \\
&= \delta(d-k)(1-x) - [(d-k^*) - (k^*-l^*)] - \delta p(1-x)(\Delta - f) \Leftrightarrow \\
&2\lambda\,[1-\delta(1-x)] + (2k - l_t)\,[1-\delta(1-x)] \\
&= 2k^* - \delta k(1-x) - l^* - \delta p(1-x)(\Delta - f) \Leftrightarrow \\
&2\lambda\,[1-\delta(1-x)] \\
&= 2k^* - 2k + 2k\delta(1-x) - \delta k(1-x) - l^* + l - l\delta(1-x) - \delta p(1-x)(\Delta - f) \\
&= 2(k^*-k) - (l^*-l) - [\delta p(\Delta - f) + (l-k)\delta](1-x) \\
&= 2(k^*-k) - (l^*-l) - (1-x)\,\theta'_{kl}.
\end{aligned}$$

It is possible to derive an explicit equation for k^M. From (31), note that $x - x_t = \lambda\frac{\overline{x}-\underline{x}}{\sigma}[1-\delta(1-x)]$, so (31) can be written as:

$$\begin{aligned}
[1-\delta(1-x)](d-k_t) + \delta(d-k)(1-x) &= \widetilde{\sigma}(1-x_t) \Leftrightarrow \\
[1-\delta(1-x)](d-k-\lambda) + \delta(d-k)(1-x) &= \widetilde{\sigma}\left(1 - x + \lambda\frac{\overline{x}-\underline{x}}{\sigma}[1-\delta(1-x)]\right) \\
&= \widetilde{\sigma}(1-x) + \lambda[1-\delta(1-x)] \Leftrightarrow
\end{aligned}$$

$$\begin{aligned}
&(2\lambda + k - d)\,[1-\delta(1-x)] = [\delta(d-k) - \widetilde{\sigma}](1-x) \Leftrightarrow \\
&2\lambda + k - d = [\delta(d-k) - \widetilde{\sigma}]\left(\frac{1-x}{1-\delta(1-x)}\right) \\
&= [\delta(d-k) - \widetilde{\sigma}]\left(\frac{\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + k - l - (1-\delta)\overline{b} + \widehat{c}}{\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \widehat{c}\right] - \delta p\Delta(1-\delta) + \delta pf}\right) \Leftrightarrow \\
&2\lambda = (d-k)\left[1 + \delta\frac{\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + k - l - (1-\delta)\overline{b} + \widehat{c}}{\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \widehat{c}\right] - \delta p\Delta(1-\delta) + \delta pf}\right] \\
&\quad - \widetilde{\sigma}\frac{\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + k - l - (1-\delta)\overline{b} + \widehat{c}}{\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \widehat{c}\right] - \delta p\Delta(1-\delta) + \delta pf},
\end{aligned}$$

which gives

$$\begin{aligned}
&2\lambda\left[\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \widehat{c}\right] - \delta(1-\delta)p\Delta + \delta pf\right]/\delta \\
&= (d-k)(k - l - p\Delta + pf + \widetilde{\sigma}/\delta) \\
&- \frac{\widetilde{\sigma}}{\delta}\left[\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + k - l - (1-\delta)\overline{b} + \widehat{c}\right],
\end{aligned} \tag{33}$$

where the right-hand side is hump-shaped and concave (and quadratic) in k. For $k_t = k$ (implying $\lambda = 0$) to constitute a stable stationary equilibrium, k must equal the largest

k satisfying the above (and the following, rewritten) quadratic equation:

$$k^2 + k\left(2\widetilde{\sigma}/\delta - p\Delta + pf - l - d\right) - d\left(\widetilde{\sigma}/\delta - p\Delta + pf - l\right) + \frac{\widetilde{\sigma}}{\delta}\left[\widetilde{\sigma}\left(1-\underline{x}\right) - \delta p\Delta - l - \left(1-\delta\right)\overline{b} + \widehat{c}\right] = 0.$$

The stable k is the largest k satisfying this equation, i.e.:

$$k^M = -\frac{2\widetilde{\sigma}/\delta - p\Delta + pf - l - d}{2} + \frac{1}{2}\sqrt{\left(2\widetilde{\sigma}/\delta - p\Delta + pf - l - d\right)^2 + 4d\left(\widetilde{\sigma}/\delta - p\Delta + pf - l\right) - 4\frac{\widetilde{\sigma}}{\delta}\left[\widetilde{\sigma}\left(1-\underline{x}\right) - \delta p\Delta - l - \left(1-\delta\right)\overline{b} + \widehat{c}\right]}$$

Since the r.h.s. of (33) is hump-shaped in k, there can be multiple stable equilibria: $k = 0$ is an equilibrium if the r.h.s. of (33) is negative at $k = 0$, i.e., if:

$$d\left(pf + \widetilde{\sigma}/\delta - l - p\Delta\right) - \frac{\widetilde{\sigma}}{\delta}\left[\widetilde{\sigma}\left(1-\underline{x}\right) - \delta p\Delta - l - \left(1-\delta\right)\overline{b} + \widehat{c}\right] < 0.$$

QED

Proof of Proposition 5:
First, notice that the following expression is linear in l:

$$\frac{x}{1-\delta\left(1-x\right)} = \frac{\widetilde{\sigma}\underline{x} + \left(1-\delta\right)\overline{b} - \widehat{c} + \delta pf + \left(1-\delta\right)\left(l-k\right)}{\left(1-\delta\right)\left[\widetilde{\sigma} - \delta p\left(\Delta - f\right) + \delta m\right] + \delta\left[\widetilde{\sigma}\underline{x} + \left(1-\delta\right)\overline{b} - \widehat{c} + \delta pf - \left(1-\delta\right)m\right]}$$
$$= \frac{\widetilde{\sigma}\underline{x} + \left(1-\delta\right)\overline{b} - \widehat{c} + \delta pf + \left(1-\delta\right)\left(l-k\right)}{\widetilde{\sigma}\left[1-\delta\left(1-\underline{x}\right)\right] + \delta\left[\left(1-\delta\right)\overline{b} - \widehat{c}\right] - \delta\left(1-\delta\right)p\Delta + \delta pf}.$$

Since this expression is linear in l, it is straightforward to maximize (13) and derive the optimal l. The first-order condition w.r.t. $l \geq 0$ is (the second-order condition holds trivially):

$$\left(a-l\right)\frac{\partial}{\partial l}\frac{x}{1-\delta\left(1-x\right)} - \frac{x}{1-\delta\left(1-x\right)} \leq 0.$$

Observation 4: If $x \downarrow 0$, this first-order condition requires $l \uparrow a$.

Otherwise, the f.o.c. can be written as:

$$\left(1-\delta\right)\left(a-l\right) - \left[\widetilde{\sigma}\underline{x} + \left(1-\delta\right)\overline{b} - \widehat{c} + \delta pf + \left(1-\delta\right)\left(l-k\right)\right] \leq 0, \tag{34}$$

with equality if $l > 0$ and if the corresponding $x < \overline{x}$. With $\widehat{c} = \underline{c}$ and $k = f = 0$, we arrive at (14).

However, note that we obtain a corner solution with $x = \overline{x}$ if (34) is positive at such a large l. From (24), we see that the required l is determined by:

$$\theta_k\left(\overline{x}\right) = \left(1-\delta\right)\overline{b} - \widehat{c} + \delta p\Delta\overline{x} + \delta p\left(1-\overline{x}\right)f + \left(l-k\right)\left[1-\delta\left(1-\overline{x}\right)\right] = \sigma \Leftrightarrow$$
$$\left(l-k\right)\left[1-\delta\left(1-\overline{x}\right)\right] = \sigma - \left(1-\delta\right)\overline{b} + \widehat{c} - \delta p\Delta\overline{x} - \delta p\left(1-\overline{x}\right)f.$$

At this l, (34) is indeed positive if

$$(1-\delta)\,a-2\,(1-\delta)\,\frac{\sigma-(1-\delta)\,\overline{b}+\widehat{c}-\delta p\Delta\overline{x}-\delta p\,(1-\overline{x})\,f}{1-\delta\,(1-\overline{x})}$$
$$>\widetilde{\sigma}\underline{x}+(1-\delta)\,\overline{b}-\widehat{c}+\delta pf+(1-\delta)\,k.$$

So, for such a large a, (A1) fails and A pays so much that $x=\overline{x}$. *QED*

Proof of Proposition 6:
The proof is analogous to the proof of Proposition 3. Note that we can write:

$$V_t^A = x_t\,(a-l_t)+(1-x_t)\,\delta V^A, \text{ where}$$
$$V^A = \frac{(a-l)\,x}{1-\delta+\delta x} \text{ and } \frac{\partial x_t}{\partial l_t} = \frac{\overline{x}-\underline{x}}{\sigma}\,[1-\delta\,(1-x)]\,.$$

Thus, the derivative of V_t^A w.r.t. l_t gives:

$$\frac{\partial V_t^A}{\partial l_t} = \frac{\overline{x}-\underline{x}}{\sigma}\,[1-\delta\,(1-x)]\left(a-l_t-\delta V^A\right)-x_t,$$

which decreases in l_t, implying that the s.o.c. holds. When this derivative equals zero, the f.o.c. holds and it can be written as:

$$\frac{\overline{x}-\underline{x}}{\sigma}\,[1-\delta\,(1-x)]\left(a-l_t-\delta V^A\right)=x_t \Leftrightarrow$$
$$[1-\delta\,(1-x)]\,(a-l_t)-\delta\,(a-l)\,x=\widetilde{\sigma}x_t \tag{35}$$
$$=\widetilde{\sigma}\underline{x}+(1-\delta)\,\overline{b}-\widehat{c}+\delta p\Delta x+\delta p\,(1-x)\,f+(l_t-k_t)\,[1-\delta\,(1-x)]\,. \tag{36}$$

Define $\eta\equiv l-l_t$. Then, when A anticipates that $k_t=k$, and with (34) describing the equilibrium under commitment, l^*, (36) can be written as:

$$\eta\,[1-\delta\,(1-x)]+(1-\delta)\,(a-l)$$
$$=(1-\delta)\,(a-l^*)-(1-\delta)\,(l^*-k^*)+\delta p\,(\Delta-f)\,x+(l_t-k_t)\,[1-\delta\,(1-x)] \Leftrightarrow$$
$$2\eta\,[1-\delta\,(1-x)]$$
$$=(1-\delta)\,(l_+-l^*)-(1-\delta)\,(l^*-k^*)+\delta p\,(\Delta-f)\,x+(l_+-k_t)\,[1-\delta\,(1-x)] \Leftrightarrow$$
$$2\eta\,[1-\delta\,(1-x)] \tag{37}$$
$$=2\,(1-\delta)\,(l_+-l^*)-(1-\delta)\,(k_t-k^*)+\delta p\,(\Delta-f)\,x+(l_+-k_t)\,\delta x$$
$$=2\,(1-\delta)\,(l_+-l^*)-(1-\delta)\,(k_t-k^*)+x\theta'_{kl}.$$

First, note that if $l_+-l^*=k_t-k^*=0$, the r.h.s. is positive iff $\theta'_{kl}>0$ so, then, $l_t<l^*$. In other words, if the contributions k^* and l^* are expected, A is tempted to lobby less than l^* iff $\theta'_{kl}>0$.

Second, in a stationary equilibrium, $\eta=0$, so l can be written as:

$$l^M=l^*-\frac{k^*-k}{2}-\frac{x\theta'_{kl}}{2\,(1-\delta)}.$$

QED

Proof of Proposition 7:
The above best-response functions (28) and (34) already permit the other payer's decision. If we combine the two to solve for $k^* - l^*$, and combine that, in turn, with (26), then we obtain (18), given that we assume interior solutions for k^* and l^*. *QED*

Proof of Proposition 8:
In a stationary equilibrium, (31) and (35) give:

$$\begin{aligned} d - k^M &= \widetilde{\sigma}(1-x) \text{ and } a - l^M = \widetilde{\sigma}x/(1-\delta)\text{, so:} \\ k^M - l^M &= d - a - \widetilde{\sigma}\left(1 - x^M\right) + \widetilde{\sigma}x^M/(1-\delta) = d - a + \left(\frac{2-\delta}{1-\delta}x^M - 1\right)\widetilde{\sigma}. \end{aligned} \quad (38)$$

When the parties can commit, as in Propositions 3 and 5, we get the same expressions for $d-k$, $a-l$, and $k-l$, as in (38), except that $\widetilde{\sigma}$ is replaced by $\widetilde{\sigma} - (\delta p\Delta - \delta pf + \delta(l^* - k^*)) = \widetilde{\sigma} - \theta^{*\prime}(x)$. This follows from Lemma 1, below. Thus:

$$\begin{aligned} k^* - l^* &= d - a + \left(\frac{2-\delta}{1-\delta}x^* - 1\right)\left[\widetilde{\sigma} - \theta^{*\prime}(x)\right] \\ &= d - a + \left(\frac{2-\delta}{1-\delta}x - 1\right)\left[\widetilde{\sigma} - \theta^{*\prime}(x)\right] + \frac{2-\delta}{1-\delta}(x^* - x)\left[\widetilde{\sigma} - \theta^{*\prime}(x)\right]. \end{aligned}$$

So, in both cases, $k-l$ increases in x, and since x increases in $k-l$, the two curves cross exactly once. (I.e., we do not have multiple equilibria.)

By combining the expression for $k^M - l^M$ and the expression for $k^* - l^*$, we get:

$$\begin{aligned} \left(k^M - l^M\right) - (k^* - l^*) &= \left(\frac{2-\delta}{1-\delta}x^M - 1\right)\widetilde{\sigma} - \left(\frac{2-\delta}{1-\delta}x^* - 1\right)\left[\widetilde{\sigma} - \theta^{*\prime}(x)\right] \Leftrightarrow \\ \left(k^M - l^M\right) - (k^* - l^*) + \frac{2-\delta}{1-\delta}\widetilde{\sigma}\left(x^* - x^M\right) &= \left(\frac{2-\delta}{1-\delta}x^* - 1\right)\theta^{*\prime}(x). \end{aligned} \quad (39)$$

Note that the two brackets on the l.h.s. have the same sign: $\left(k^M - l^M\right) > (k^* - l^*) \Leftrightarrow x^* > x$. Hence, both these equalities hold if the r.h.s. of (39) is positive, and both fails if the r.h.s. is negative. *QED*

Lemma 1: *Under commitments, we have*

$$\begin{aligned} d - k^* &= (1 - x^*)\left[\widetilde{\sigma} - (\delta p\Delta - \delta pf + \delta(l^* - k^*))\right] \text{ and} \\ a - l^* &= \frac{x^*}{1-\delta}\left[\widetilde{\sigma} - (\delta p\Delta - \delta pf + \delta(l^* - k^*))\right]. \end{aligned}$$

Proof: As an alternative to the proof of Proposition 3, we can derive k^* from the following f.o.c.:

$$
\begin{aligned}
(d-k)\frac{\partial}{\partial k}\left(\frac{1-x}{1-\delta(1-x)}\right)-\frac{1-x}{1-\delta(1-x)} &= 0 \Leftrightarrow \\
(d-k)\frac{-1+\delta(1-x)-\delta(1-x)}{[1-\delta(1-x)]^2}\frac{\partial x}{\partial k}-\frac{1-x}{1-\delta(1-x)} &= 0 \Leftrightarrow \\
(d-k)\frac{-1}{1-\delta(1-x)}\frac{\partial x}{\partial k} &= 1-x \Leftrightarrow \\
\frac{V^D}{1-x}\frac{\partial(1-x)}{\partial k} &= 1-x \Leftrightarrow \\
\frac{d-k}{1-\delta+\delta x}\frac{[1-\delta(1-x)]}{\widetilde{\sigma}-(\delta p\Delta-\delta pf+\delta(l-k))} &= 1-x \Leftrightarrow \\
\frac{d-k}{\widetilde{\sigma}-(\delta p\Delta-\delta pf+\delta(l-k))} &= 1-x. \qquad (40)
\end{aligned}
$$

And, as an alternative to the proof of Proposition 5, l^* can be derived as follows:

$$
\begin{aligned}
(a-l)\frac{\partial}{\partial l}\left(\frac{x}{1-\delta(1-x)}\right)-\frac{x}{1-\delta(1-x)} &= 0 \Leftrightarrow \\
(a-l)\frac{1-\delta(1-x)-\delta x}{[1-\delta(1-x)]^2}\frac{\partial x}{\partial l}-\frac{x}{1-\delta(1-x)} &= 0 \Leftrightarrow \\
(a-l)\frac{1-\delta}{[1-\delta(1-x)]}\frac{\partial x}{\partial l} &= x \Leftrightarrow \\
(a-l)\frac{1-\delta}{[1-\delta(1-x)]}\frac{[1-\delta(1-x)]}{\widetilde{\sigma}-(\delta p\Delta-\delta pf+\delta(l-k))} &= x \Leftrightarrow \\
(a-l)\frac{1-\delta}{\widetilde{\sigma}-(\delta p\Delta-\delta pf+\delta(l-k))} &= x. \qquad (41)
\end{aligned}
$$

QED

Proof of Proposition 9:
First, notice that f has the same role as αk_R. If we set f, which is defined as $\widehat{c}-\underline{c}$, equal to αk_R in (24), we obtain the expression for $\theta_R(x)$. With this, the proposition follows straightforwardly from the first-order conditions of the Lagrange problem (20). *QED*

Proof of Proposition 10:
The proof follows from the reasoning in the text. *QED*

Proof of Proposition 11:
With the budget K, D's objective is

$$
(d-K)\frac{1-x}{1-\delta(1-x)}, \text{ where}
$$

$$
K = k + k_G + k_R, \text{ and}
$$

$$\frac{1-x}{1-\delta(1-x)} = \frac{\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + k - l - (1-\delta)\overline{b} + \widehat{c}}{\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \widehat{c}\right] - \delta(1-\delta)p\Delta + \delta pf}$$
$$= \frac{\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + k - l - (1-\delta)\overline{b} + \underline{c} + f}{\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \underline{c} - f\right] - \delta(1-\delta)p\Delta + \delta pf}$$
$$= \frac{\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + [K - k_G - k_R] - l - (1-\delta)\overline{b} + \underline{c} + \gamma k_G + \alpha k_R}{\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \underline{c} - \gamma k_G - \alpha k_R\right] - \delta(1-\delta)p\Delta + \delta p\alpha k_R},$$

when we substitute for the budget, i.e., $k = K - k_G - k_R$. The derivative w.r.t. k_G is:

$$-(1-\gamma)\left[\widetilde{\sigma}[1-\delta(1-\underline{x})] + \delta\left[(1-\delta)\overline{b} - \underline{c} - \gamma k_G - \alpha k_R\right] - \delta(1-\delta)p\Delta + \delta p\alpha k_R\right]$$
$$+\delta\gamma\left[\widetilde{\sigma}(1-\underline{x}) - \delta p\Delta + [K - k_G - k_R] - l - (1-\delta)\overline{b} + \underline{c} + \gamma k_G + \alpha k_R\right],$$

which is positive if K is sufficiently large.

The same qualitative statement can easily be obtained if we instead take the derivative w.r.t. k_R, and also if we set $k_R = K - k - k_G$ and then take the derivative w.r.t. k_G. *QED*

Proofs of Propositions 12-14:
The derivation of (8) is analogous to the proof of Proposition 1. When we solve the two equations we get:

$$x^i = \underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[\delta\Delta p^i x^j + (1-\delta)\overline{b}^i - \underline{c}^i\right]$$
$$= \underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[(1-\delta)\overline{b}^i - \underline{c}^i\right] + \frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^i x^j$$
$$= \underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[(1-\delta)\overline{b}^i - \underline{c}^i\right] + \frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^i\left[\underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[(1-\delta)\overline{b}^j - \underline{c}^j\right] + \frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^j x^i\right] \Leftrightarrow$$

$$x^i\left(1 - \left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^i\right)\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^j\right)\right)$$
$$= \underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[(1-\delta)\overline{b}^i - \underline{c}^i\right] + \frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^i\left[\underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[(1-\delta)\overline{b}^j - \underline{c}^j\right]\right] \Leftrightarrow$$
$$x^i = \frac{\underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[(1-\delta)\overline{b}^i - \underline{c}^i\right] + \frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^i\left[\underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left[(1-\delta)\overline{b}^j - \underline{c}^j\right]\right]}{1 - \left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2 p^i p^j}.$$

If every $\overline{b}^i = \overline{b}$ and $\underline{c}^i = \underline{c}$, we get:

$$x^i = \frac{\left[\underline{x} + \frac{\overline{x}-\underline{x}}{\sigma}\left(1 + \frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^i\right)\right]\left[(1-\delta)\overline{b} - \underline{c}\right]}{1 - \left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2 p^i p^j},$$

so $x^i > x^j$ iff $p^i > p^j$, assuming $(1-\delta)\overline{b} > \underline{c}$.

Expected exploitation is:

$$
\begin{aligned}
&\left(1-p^{i}\right)x^{i}+p^{i}x^{j}\\
&=\left(1-p^{i}\right)\frac{\left[\underline{x}+\frac{\overline{x}-\underline{x}}{\sigma}\left(1+\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^{i}\right)\right]\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}p^{i}p^{j}}\\
&+p^{i}\frac{\left[\underline{x}+\frac{\overline{x}-\underline{x}}{\sigma}\left(1+\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^{j}\right)\right]\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}p^{i}p^{j}}\\
&=\left(1-p^{i}\right)\frac{\left[\underline{x}+\frac{\overline{x}-\underline{x}}{\sigma}\left(1+\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^{i}\right)\right]\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-}{\sigma}\delta\Delta\right)^{2}p^{i}p^{j}}\\
&+p^{i}\frac{\left[\underline{x}+\frac{\overline{x}-\underline{x}}{\sigma}\left(1+\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta p^{j}\right)\right]\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}p^{i}p^{j}}\\
&=\frac{\left[\underline{x}+\frac{\overline{x}-\underline{x}}{\sigma}\left(1+2\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\left(1-p^{i}\right)p^{i}\right)\right]\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}\left(1-p^{i}\right)p^{i}},
\end{aligned}
$$

which is maximized at $p^{i}=1-p^{i}=1/2$.

Difference in exploitation:

$$
x^{i}-x^{j}=\frac{\left[\frac{\overline{x}-\underline{x}}{\sigma}\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\left(p^{i}-\left(1-p^{i}\right)\right)\right)\right]\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}p^{i}p^{j}}=\frac{\delta\Delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^{2}\left(2p^{i}-1\right)\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}\left(1-p^{i}\right)p^{i}}.
$$

The median voter's utility is (V^{m} is the *expected* continuation value if the resource has not been exploited):

$$
\begin{aligned}
V_{i}^{m}&=bx^{i}+\left(1-x^{i}\right)\left(c+\delta V^{m}\right)\\
V_{i}^{m}-V_{j}^{m}&=\left(x^{j}-x^{i}\right)\left(c+\delta V^{m}-b\right).
\end{aligned}
$$

With probabilistic voting and symmetrically and uniformly distributed relative popularity shock, i wins with probability:

$$
1-p^{i}=\frac{1}{2}+\varsigma\left(x^{j}-x^{i}\right),
$$

where ς is equal to the density of the shock multiplied by $(c+\delta V^{m}-b)$. When we substitute in for $(x^{j}-x^{i})$, we get:

$$
\begin{aligned}
1-p^{i}&=\frac{1}{2}+\varsigma\frac{\delta\Delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^{2}\left(1-2p^{i}\right)\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}\left(1-p^{i}\right)p^{i}},\text{ or}\\
p^{j}-p^{i}&=2\varsigma\frac{\delta\Delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^{2}\left(p^{j}-p^{i}\right)\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^{2}\left(1-p^{i}\right)p^{i}}.
\end{aligned}
$$

which pins down p^i, and thus the x's. In particular, p^i is:

$$1-2p^i=2\frac{\delta\Delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^2\left(1-2p^i\right)\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2\left(1-p^i\right)p^i}$$

$$1-\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2\left(1-p^i\right)p^i=2\delta\Delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^2\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]$$

$$\left(1-p^i\right)p^i=\frac{1-2\delta\Delta\left(\frac{\overline{x}-\underline{x}}{\sigma}\right)^2\left[\left(1-\delta\right)\overline{b}-\underline{c}\right]}{\left(\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta\right)^2},$$

which clearly gives multiple (two) equilibria, and there is more asymmetry (i.e., larger $|p^i-p^j|$) if the r.h.s. is small: I.e., if $\frac{\overline{x}-\underline{x}}{\sigma}\delta\Delta$ and $\left(1-\delta\right)\overline{b}-\underline{c}$ are large. *QED*

Proof of Proposition 15:
Let the office rent be R and suppose $p^B>p^A$. If the resource is exploited, however, the resource is no longer an electoral issue and thus suppose both probabilities are 1/2 and each continuation value is $V_0^P=R/2\left(1-\delta\right)$.

P_t receives $\overline{b}$ if he cuts now. Suppose that if P_t does not cut now, then his party will cut with probability y any later period it is in power, while the opposition exploits with probability x any period P_t's party is not in power. With this, the current P_t's continuation value at the beginning of any *later* period, $\tau>t$, is:

$$\begin{aligned}V^B&=\left(1-p^B\right)R+\left(1-p^B\right)x^B\left(\overline{b}+\delta V_0^P\right)+p^Bx^A\left(b+\delta V_0^P\right)\\&\quad+\left(1-p^B\right)\left(1-x^B\right)\left(\widehat{c}_P+\delta V^P\right)+p^B\left(1-x^A\right)\left(c_P+\delta V^P\right)\\&=\frac{\left(1-p^B\right)R+\left(1-p^B\right)x^B\left(\overline{b}+\delta V_0^P\right)+p^Bx^A\left(b+\delta V_0^P\right)}{1-\delta\left(1-p^B\right)\left(1-x^B\right)-\delta p^B\left(1-x^A\right)}\\&\quad+\frac{\left(1-p^B\right)\left(1-x^B\right)\widehat{c}_P+p^B\left(1-x^A\right)c_P}{1-\delta\left(1-p^B\right)\left(1-x^B\right)-\delta p^B\left(1-x^A\right)}.\end{aligned}$$

P_t prefers to cut now if:

$$\begin{aligned}&k+\widehat{c}_P+\delta V^B<\overline{b}+l+\delta V_0^P\Leftrightarrow\\&\delta\frac{\left(1-p^B\right)R+\left(1-p^B\right)x^B\left(\overline{b}+\delta V_0^P\right)+p^Bx^A\left(b+\delta V_0^P\right)}{1-\delta\left(1-p^B\right)\left(1-x^B\right)-\delta p^B\left(1-x^A\right)}\\&+\delta\frac{\left(1-p^B\right)\left(1-x^B\right)\widehat{c}_P+p^B\left(1-x^A\right)c_P}{1-\delta\left(1-p^B\right)\left(1-x^B\right)-\delta p^B\left(1-x^A\right)}\\&<\overline{b}+\delta V_0^P+l-k-\widehat{c}_P.\end{aligned}$$

With $\widehat{c}_P = c_P$, and $l = k = 0$, we get:

$$\begin{aligned}
&\delta\left[\left(1-p^B\right)R + \left(1-p^B\right)\left(\overline{b}+\delta V_0^P\right) + p^B x^A\left(b+\delta V_0^P\right) + p^B\left(1-x^A\right)c_P\right] \\
&< \left(\overline{b}+\delta V_0^P - \widehat{c}_P\right)\left[1-\delta p^B\left(1-x^A\right)\right] \Rightarrow \\
&\delta\left(1-p^B\right)R + \left[\delta - \delta p^B\left(1-x^A\right) - \left[1-\delta p^B\left(1-x^A\right)\right]\right]\left(\overline{b}+\delta V_0^P\right) - \delta p^B x^A \Delta \\
&< -\widehat{c}_P\left[\delta p^B\left(1-x^A\right) + 1 - \delta p^B\left(1-x^A\right)\right] \Rightarrow \\
&\delta\left(1-p^B\right)R - [1-\delta]\left(\overline{b}+\delta V_0^P\right) - \delta p^B x^A \Delta < -\widehat{c}_P \Rightarrow
\end{aligned}$$

$$\begin{aligned}
\theta_t &< \delta p^B x^A \Delta + [1-\delta]\left(\overline{b}+\delta V_0^P\right) - \delta\left(1-p^B\right)R - \underline{c} \Rightarrow \\
\theta_t &< \delta p^B x^A \Delta + [1-\delta]\left(\overline{b}+\delta \frac{R}{2\left(1-\delta\right)}\right) - \delta\left(1-p^B\right)R - \underline{c} \Rightarrow \\
\theta_t &< \delta p^B x^A \Delta + [1-\delta]\,\overline{b} + \delta\left(\frac{1}{2} - \left(1-p^B\right)\right)R - \underline{c} \Rightarrow \\
\theta_t &< \delta p^B x^A \Delta + \delta\left(p^B - \frac{1}{2}\right)R + [1-\delta]\,\overline{b} - \underline{c}.
\end{aligned}$$

So, the minor (major) party becomes more (less) likely to exploit (regardless of the sign of Δ).

The derivation of the equilibrium p^i is similar to the previous proof. Thus, the larger polarization increases the difference in p^i, strengthening the polarization in x^i, etc. *QED*

Proofs of Propositions 16-18:
These proofs are in the text. *QED*

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