Corruption, Conflict and the Management of Natural Resources

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Abstract

The documented link between natural resources and civil conflict is not well understood. This paper uses a political economy framework to explore the emergence of resource-based civil conflict driven by group-level discontent. Previous models of resource conflicts are premised on the idea that the desire of enrichment by appropriating resources is the driving force for insurgents. This approach, however, treats the management of the contentious resources as exogenous, while also failing to account for the grassroots dissatisfaction that is often reported to spark and/or sustain rebellions. The proposed theoretical model offers a policy-based alternative: under conditions related to the quality of governance, discontent about resource management can be instrumental in increasing the likelihood of an insurgency. While influential contributions in the literature tell the 'resource abundance implies opportunity, implies greed-based conflict' story, this paper focuses on relative scarcity to justify discontent and prompt a 'grievance-based' rebellion. The resource policy arises endogenously as the corrupt government trades off industry contributions and the cost induced by manifestations of resource-related discontent. Conservation effects of both *internal pressure*, in the form of civil unrest, and *external pressure* in the form of international trade and aid measures are analyzed in turn, and regulator corruption is shown to be an important ingredient of conflict. The last part presents some empirical evidence in support of the model's predictions.

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1. Introduction

Economic policy-making is often responsible for the disenfranchisement of some groups in society. There is usually more than one interest group vieing for the regulator's favours, and systematically discriminating against one side has the potential to generate conflict. Economic discontent may erupt into violence where the obstacle to a peaceful resolution of disputes is difficult to circumvent. Many economic activities can simply re-locate when the business environment is not satisfactory, so that tensions due to regulation or re-distribution do not accumulate. Natural resources are, however, highly location-specific, and thus grievances are more prone to escalate into open conflicts. There are numerous accounts of a link between natural resources and the prevalence of violence. '[In] many cases, central governments promote unsustainable mining, logging, ranching, and other projects... [which] typically help prop up unrepresentative, sometimes repressive regimes and enrich national elites and foreign corporations, with few benefits accruing to those whose lands are devastated.'[1] Natural resource management decisions, in both the developing and developed countries, are still significantly skewed towards meeting political goals. On the other hand, resource-related violence is an important phenomenon. According to some estimates, more than one in five conflicts worldwide are resource-based,[2] and civil conflicts dwarf inter-state conflicts in terms of casualties, duration and number of participants.[3] Moreover, there is substantial case-study evidence of resource conflicts triggered by an insensitivity to local concerns of an alliance formed by an opportunistic government and extractive industry interests.[4]

[1] See Renner (1996), p. 59.

[2] See Renner (2002), p. 6.

[3] See Fearon and Laitin (2003), p. 75.

[4] E.g. in Indonesia, the Aceh conflict against the government and ExxonMobil, in Papua New Guinea, the Bougainville conflict against the government and the mining corporation RTZ, in Nigeria, the Niger Delta conflict against Royal Dutch/Shell and other Western oil giants and the government are just some of the

This paper uses a political economy framework to explore how conflict can occur if resource management policies fail to address particular interest group concerns. Although the most common narrative of the origins of civil violence episodes involves some form of group grievances, existing economic models of conflict are instead premised on the idea that the desire of enrichment by resource appropriation is the cause of most rebellions. Moreover, this approach fails to account for the critical support for insurgency of a significant share of the population that is often apparent especially in the initial phases, [5] while the empirical support for this view is not robust. The theoretical model proposed here offers a policy-based alternative: legitimate grievances related to the way in which resources are managed can translate into violence. While the real motivations of rebel leaders are often hard to interpret, they are not important for our framework. What is required is only a policy-related group-level discontent that can sustain an eventual uprising.[6] While the *appropriation* mechanism lacks a clear policy recommendation, the *policy* channel prescribes that devising a more inclusive resource policy has the potential to reduce the incidence of civil conflicts. The focus is first on the government's resource policy, a function of the quality of governance. The resulting environmental outcome may spark legitimate resource-related discontent, regardless of the

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largest ones. See Regan in Ballentine and Sherman (eds) (2003), p. 133-166 and Renner (2002), p. 40-47.

[5] Often, declared motives may also proxy for additional underlying causes, while in other instances claims for socio-political justice may mask predatory intentions. E.g. the separatist Papuan Freedom Organization 'did not gain much support from the local population until the 1970s, when it harnessed grievances against a large-scale mining operation.' Renner (2002), p. 43.

[6] According to October 31, 2009 edition of the Globe and Mail, Somalia's prime minister maintains Somali pirates are former fishermen driven to poverty by excessive international fishing in Somali waters. A New York Times article on November 1, 2009 describes how maoist rebels in the Indian state of Chattisgarh 'accuse the government of trying to push tribal groups off their land to gain access to raw materials and have sabotaged roads, bridges and even an energy pipeline'. See *http://www.nytimes.com/2009/11/01/world/asia/01maoist.html?_r=1*.

eventual unfolding of the conflict or shifts in rebels' motivations. Resource depletion may also have regional consequences, for which international intervention might be appropriate. Hence, the model also investigates the effects of international trade measures and of international transfers on such an environment. Specifically, the paper asks whether these 'external pressures', which may complement the 'internal' constraint represented by the possibility of domestic violence against a corrupt government, are instrumental in curbing depletion, thus indirectly reducing the likelihood of conflict.

There are three agents in this economy: the self-interested government which is responsible for making resource management decisions, the large scale resource extractive industry which can influence policy through regulation - contingent payments, and the small-scale subsistence harvesters who live off the resource and can migrate to take payoff-improving outside opportunities. In a majority of available examples, the basic scenario is similar: wide-scale exploitation of a natural resource benefits large corporations and the financially interested government, while damaging the environment and threatening the way of life of local populations.[7]

The main results of the paper are the following. Absent the shadow of conflict, the opportunistic government attaches a lower effective weight to locals' concerns and sets a larger harvesting quota than optimal, and resource exploitation increases with the corruption of the government and with its myopia, i.e. the rate of time preference parameter. The specter of conflict decreases exploitation in certain environments, where conditions are such that the increased discontent of the locals dominates their induced emigration. While corruption

[7] 'In many developing countries, the economic benefits of mining and logging operations accrue to a small business and government elite and to foreign investors. But in case after case, an array of burdens - ranging from expropriation of land, disruption of traditional ways of life, environmental devastation, and social maladies - are shouldered by the local population.' Renner (2002), p. 8.

is generally detrimental to stability since it indirectly increases conservationist grievances, more corruption could actually reduce the conflict-generating effect of depletion, a somewhat counter-intuitive finding. Good outside opportunities available for subsistence harvesters fosters migration and has a negative effect, while the level of population has a positive effect on the likelihood of conflict. Provided the parameters are such that the equilibrium level of the resource is not too low, international sanctions targeting the resource management process (in an environment where the government is corrupt and conflict is possible) achieve their conservationist goal whenever they result in producer price reductions, while the effectiveness of conditional international aid can be directly related to government corruption. Thus, the quality of governance plays an important role in assessing the effects of both external (trade or aid) and internal (political violence) pressure.

Most studies on the relationship between resources and conflict - and especially those proposing predatory behaviour as the dominant mechanism for civil conflict - look at easily lootable, high value non-renewables, such as precious minerals. To offer a complementary perspective, the present theoretical model incorporates renewable resources, typically less prone to violent appropriation.[8] Most civil wars occur in developing countries, where large groups depend on the environment for subsistence,[9] and it is broadly agreed that 'most life-giving [natural] resources are renewable'.[10] Alternatively, the model can support the more general interpretation of being concerned with a population's discontent over the general state of the natural environment as managed by a corrupt regime, including deforestation, severe

[8] Renner (2002) notes that when resource *wealth* is the cause of conflict, it is usually associated with lootable minerals, while *scarcity* is more often linked with renewables (p. 9.).

[9] Civil wars in Indonesia, Cambodia, Burma, Liberia and the Democratic Republic of Congo have involved timber. In the Ivory Coast, cacao and cotton, along with diamonds, are documented to have been connected to the conflict. See the report by Global Witness at http://www.globalwitness.org/pages/en/cote_divoire.htm.

[10] See Reuveny and Maxwell (2001), p. 720.

overexploitation of fisheries, soil degradation, water crises, and the two parties competing for the government's favours can be called *harvesters* and *conservationists*.[11]

The economics of conflict is an emerging sub-field in the discipline. In an excellent recent overview of the literature, Blattman and Miguel (2009) express the widely-held view that the diversity of results and the apparent lack of convergence in the empirical literature on civil conflicts is at least in part due to insufficient theoretical modelling. Hirschleifer and Grossman pioneered the theory of appropriative conflict, where two symmetrical sides, choosing from the same set of actions, optimally allocate their resources to production, soldiering and insurgence, and where conflict arises as an equilibrium outcome when parameters are such that a probability of insurgence success is high.[12] In this tradition, Olsson (2007) presents a predator-prey model where the ruler is assumed to own all resources, while the rebels' claim is predatory, and tests the theoretical predictions for the case of the rough diamond industry. The study is complementary to the one in this paper, in that here the motivation lies in the legitimate resource policy driven claims by marginalized interest groups dependent on the life-sustaining resources.

Most models in this literature are essentially static,[13] while resource rents are exogenous. Prominent empirical studies on the topic of resource-driven civil conflicts, starting with the series by Collier and Hoeffler as part of the World Bank project on the Economics of Civil War, Crime and Violence, report economic opportunity - the 'greed' motivation - as pre-

[11] The natural processes by which the environment absorbs part of the industrial impact would correspond to stock depletion. This broad view can accommodate situations where unrelated industrial or extractive activities damage the environment, like in the Niger Delta, while the government fails to let locals share in the resource revenue bounty as compensation for their lost livelihood.

[12] See Neary (1997) for a comparison between rent-seeking and conflict models.

[13] In a recent review, Garfinkel and Skaperdas (2006) point out that 'only the surface of the dynamic effects of conflict has been scratched.' (p. 54.)

dominant explanation of internal violence. However, many of these results are not robust to the definition of conflict, of resource-dependence or the particular sample of countries or year of analysis.[14] A recent paper by Collier and Hoeffler (2009) focuses on resource rents instead of 'abundance' and looks at the interaction with democracy on growth rates, yet it does not endogenize the formation of the rents via a structured policy making process and it does not include conflict. The approach in this paper resembles the ones in Damania and Barbier (2001) and Barbier et al.(2005), who present, respectively, political economy models of renewable and non-renewable resource harvesting and focus on trade policy instruments and resource conversion. This paper differs chiefly in structuring the interaction among three groups of players with distinct objectives and in focusing on resource-based civil conflict. The present model is inherently dynamic, featuring the intertemporal management of a renewable resource (which could be broadly interpreted as *the environment*), endogenizes the resource policy and also allows for an asymmetrical treatment of the government and potential rebel sides.

The rest of this work is structured as follows. The next section looks at the quality of governance as driving policies susceptible to generate discontent and it presents the no-conflict opportunistic government equilibrium in contrast to the the 'no-corruption' first best benchmark. The following section allows for internal conflict to be a factor and studies properties of an equilibrium where costly manifestations of discontent factor into the government's decision making. In addition, the section discusses how resource depletion and the quality of governance may influence the emergence of full scale conflicts. The effects of possibly complementary external conservationist pressure in the form of trade sanctions and aid conditional on resource conservation performance are then analyzed. The third part of the paper summarizes

[14] As Hegre and Sambanis (2006) contend in a recent study that undertakes a 'global sensitivity analysis' of these studies p. 509.

the main findings and concludes.

2. A Political Economy Model of Renewable Resource Exploitation

Many resource-based conflicts around the world are about minerals, yet there are also numerous cases where renewable resources are involved. It is generally considered that - with the exception of water - renewable resources are more likely to generate internal conflicts than international ones, due to the fact that 'states cannot easily convert cropland, forests and fish seized from a neighbour into increased state power'.[15] Apart from timber, fish stocks and wildlife are also over-exploited across the world, with their management being least effective or non-existent mostly in the unstable areas of the world. Governments in developing countries consistently augment their revenues by granting exploitation rights to domestic or foreign private interests or foreign countries, at times at the expense of the locals.[16]

2.1. Peaceful Resource (mis)Management

The three agents in the model are: the government deciding on the exploitation rate of a renewable resource, the extractive industry acting like an organized group to lobby the government for higher than optimal quotas, and the local peasants, each harvesting a subsistence amount of the resource. The paper first looks at the case where conflict is not an option, possibly due to the fact that harvesters cannot resolve their collective action problem. When subsequently allowing for the prospect of conflict to play a role, it is assumed - also

[15] Homer-Dixon (1999), p. 138.

[16] Senegal made international headlines in 2006 when denouncing a previous contract that allowed EU vessels to fish in Senegalese waters and that severely depleted fish stocks local fishermen had been dependent upon for generations. The European Union holds similar agreements with most African coastal states, whereby European fishermen are allowed to harvest in African waters for a fixed overall sum that many argue understate the true environmental cost.

without modeling that particular game - that harvesters have overcome the free riding obstacle and are able to challenge the government.

The resource exploitation regime is modeled as follows: the industry presents the government with a 'bribe schedule' that relates contribution payments to harvesting quotas.[17] The government takes this schedule as given and maximizes its own utility function that depends on the welfare of the sector and the contributions it gets from the big industry to set the quota at a high level.[18] While the industry only values the proceeds from harvesting, the locals' very existence is linked to the resource.[19] The way this feature is modeled here is the following: the individual utility function of a local harvester is equal to the amount of the resource required for subsistence $\bar{h}$, less the disutility of effort required to harvest it. Peasants are heterogeneous with respect to their harvesting ability q_i and their harvesting function equals the product of combining three inputs: the harvesting ability, the level of the resource stock and labour: $\bar{h} = q_i S l_i$. Their preferences are represented by a (disaggregated) utility function of the following form:

$$u_i(\bar{h}, l_i) = \bar{h} - l_i = \bar{h} - \tfrac{\bar{h}}{q_i S}.$$

[17] Similar, e.g. to Grossman and Helpman (1994).

[18] The monetary contribution paid by the industrial sector to the government is called 'bribe'. To be exact, however, this terminology is only accurate from the point of view of the government, who embezzles the quota rights. From the firm's point of view, 'the bribe' is just the cost of obtaining the harvesting licence. In theory, this should be illicit from the company's perspective when the amount paid to the government would not be enough to compensate for the true social welfare cost of harvesting. However, no restrictive assumptions are made in this respect here.

[19] This responds in part to some critics of the economics models of conflict contending that the exclusively extrinsic, payoff-motivated players are incompatible with the many documented instances of *intrinsically motivated* actors. See e.g. Cramer (2002) 'Homo Economicus Goes to War'.

Peasants 'migrate'[20] or pursue outside opportunities, represented by a unit labour wage w,[21] treated as exogenous, if they can improve their payoff. In the present context this means working less in order to earn the subsistence amount $\bar{h}$. The individual peasant i remains a harvester as long as the utility she would get by taking the alternative opportunity does not exceed the status quo payoff: $u_i(\bar{h}, l_i) \geq u_i(\bar{h}, l_i')$, equivalent to $l_i \leq l_i'$ or $\frac{\bar{h}}{q_i S} \leq \frac{\bar{h}}{w}$ which implies

$$q_i \geq \frac{w}{S},$$

and takes the superior outside option otherwise. As the resource gets depleted, the local resource-dependent population decreases, and so does their group strength.[22]

Assuming that harvesting ability is uniformly distributed in the total peasant population on an interval defined by two extreme values that are determined by an initial distribution and past migrations, $q_i \sim U[\underline{q}, \bar{q}]$, the fraction of the normalized initial population that remains at every level of the resource stock is $L(S, w) = (\bar{q} - \frac{w}{S})$, while the mass of city migrants equals $(\frac{w}{S} - \underline{q})$.[23] The rural harvesting population decreases as the resource is depleted and it becomes increasingly difficult to provide sustenance to everyone, and also decreases when outside opportunities become more attractive: $L_S > 0$ and $L_w < 0$.

Suppose the peasant population matters for the government, for instance in their role as voters, a common assumption in the political economy literature. Then, even an opportunis-

[20] This does not have to involve physical migration, only disconnect from the resource.

[21] The amount w can be thought of as the minimum wage in the neighbouring city, region or country where migration is feasible.

[22] The decrease is less than proportional if one assumes harvesting ability is positively correlated with fighting ability.

[23] Notice that the formula for the number of locals remaining is robust to subsequent migrations: as the low ability types leave, the lower bound of the ability interval moves to the right, yet the upper bound remains fixed.

tic regulator 'cares' about social welfare, along with bribes. The aggregate utility of small harvesters is the sum of the utilities of locals remaining in the rural area and the city migrants: $u = u^r + u^c$. To obtain the aggregate utilitarian u^r, integrate the individual utilities of the remaining locals on the relevant support as follows:

$u^r = \int_{\frac{w}{S}}^{\bar{q}} u_i dq_i = \int_{\frac{w}{S}}^{\bar{q}} (\bar{h} - \frac{\bar{h}}{q_i S}) dq_i = \bar{h}(\bar{q} - \frac{w}{S}) - \frac{\bar{h}}{S} \ln \frac{\bar{q}S}{w}$. Similarly, adding the welfare of migrants yields

$u^c = \int_{\underline{q}}^{\frac{w}{S}} (\bar{h} - \frac{\bar{h}}{w}) dq_i = \bar{h}(1 - \frac{1}{w})(\frac{w}{S} - \underline{q})$, so that the aggregate utility of peasants can be written as:

$$U(S) = \bar{h}(\bar{q} - \underline{q}) - \frac{\bar{h}}{S} \ln \frac{\bar{q}S}{w} - \frac{\bar{h}}{w}(\frac{w}{S} - \underline{q}).$$

It follows that the marginal utility of a resource unit is: $U_S = \frac{\bar{h}}{S^2} \ln \frac{\bar{q}S}{w} > 0$, and the second derivative $U_{SS} = \frac{\bar{h}}{S^3}(1 - 2 \ln \frac{\bar{q}S}{w}) < 0$.

The industrial and small scale harvesters always coexist in this model. The paper assumes for simplification that the profit function of the industrial sector is such that profits are positive or the firm is active for all relevant stock levels and prices. In other words, the extraction technology is assumed to be 'advanced enough' to yield positive profits even at low levels of the resource. For tractability it is assumed that all agents discount the future at the same rate. The resource management instrument chosen by the government is a quota on harvesting, which is the predominant form of resource and environment protection policies worldwide.[24]

We are interested in how the quality of governance affects the environmental outcome. As a benchmark, consider first the first-best case where there is no corruption. Let $\pi(p, H, S)$

[24] The quota does not bind the small-scale harvesters due to the impossibility of enforcement and/or the fact that the government trusts the 'environmentally responsible' locals not to over-deplete the resource, or the fact that the local subsistence harvesting is of a much lower order of magnitude than the Total Allowable Catch (TAC) or, like in many communities in North-America, the existence of treaties which allow harvesting privileges for locals.

be the industry's total profit, increasing in all arguments: the price of the final resource good, the harvesting quantity and the stock of the resource, since harvesting costs are assumed to increase with resource scarcity. Denote by δ the rate of time preference in the society, and by $F(S)$ the natural growth function of the resource, which is assumed to be strictly concave. An *honest government* maximizes the discounted present value of a social welfare function of the following form:

$$\underset{Q}{Max} \quad \int_0^\infty e^{-\delta t}[\pi(p, H, S) + U(S)]dt \;\; \text{subject to} \;\; \dot{S} = F(S) - H - \bar{H}$$

and $H \leq Q$.

The first constraint is represented by the growth of the stock, which depends on a natural growth function F(S) and the combined harvesting H and $\bar{H}$, where the latter represents the subsistence amount harvested on aggregate by the local peasants: $\bar{H}(S) = \bar{h}(\bar{q} - \frac{w}{S})$. The second constraint provides that industrial harvesting H does not exceed the total allowable catch Q and will be binding at optimum. I assume lump-sum transfers are ruled out, perhaps because of a significant marginal cost of public funds, and the only distributional channel is via the resource policy.

Optimal harvesting regulated by an honest government without the possibility of conflict satisfies the following steady-state decision rule, as detailed in the Appendix, section (1):

$$(F_S - \bar{H}_S) + \frac{\pi_S + U_S}{\pi_Q} = \delta. \tag{1}$$

This is a version of the augmented *modified golden rule* of renewable resource exploitation introduced by Clark and Munro (1975).[25] The last term on the left-hand-side constitutes the marginal stock effect (MSE). This arises since in this setting welfare depends not only on the flow of harvesting, but also on the stock of the resource via its effect on harvesting costs for

[25] See also Munro (1979), p. 5.

the industry as well as for the locals. Drawing a parallel to capital theory, the above equation states that it is optimal to invest in the resource by abstaining from harvesting until the net marginal resource yield ($F_S - \bar{H}_S$), augmented to account for the effects on industry profits and locals' utility, equals the social rate of discounting the future. In other words, the left hand side represents the social return from conserving one unit of the resource, while the right hand side is the social cost of doing so. Alternatively, the MSE can be re-written as the society's 'marginal rate of substitution' between keeping the resource *in situ* and harvesting it: if W^h is the welfare function of the honest government described above, $W^h_Q = \pi_Q$ and the marginal welfare effects of harvesting and resource level are calculated as: $W^h_S = \pi_S + U_S|_{H=H^*}$, then the marginal stock effect $MSE = \frac{W^h_S}{W^h_Q}$. The expression in (2.1) yields a unique stationary resource stock level achieved under an honest government, which is denoted by S^h.[26]

When corruption is present, there is scope for strategic industry-regulator interaction. To keep things standard, the *menu auction* introduced by Bernheim and Whinston (1986) is assumed as framework for the game, as it has served as the workhorse model for most recent political economy studies, starting with Grossman and Helpman (1994). The extractive interest group presents the government with a bribe schedule that relates contributions to policy alternatives. The government then chooses the policy measure by trading off bribe revenues and losses in welfare brought about by the socially inefficient choice induced by the contributions. The firms harvest according to the set quota level and pay the corresponding bribe to the government. Denoting by $G = W + \beta B$ the utility function of the government, as a sum of the social welfare and the value of the contributions, and by π the gross industry profit, Bernheim and Whinston (1986) show that the 'truthful' equilibrium harvesting has to satisfy the following: $(C_1) : Q = argmax_H\{G\}$ and $(C_2) : Q = argmax_H\{G + \pi\}$.[27] If the

[26] See Clark and Munro (1975), p. 95.

[27] See Lemma 2, op.cit., p. 10. A similar approach is adopted in Barbier et al.(2005).

above conditions were not satisfied, it would be possible for the firm to adjust its contribution schedule so as to induce the government to maximize the joint surplus, while keeping most of the gain for itself.[28]

An implicit assumption is that all agents are forward-looking, and that property rights are enforced.[29] This simplification allows one to avoid diverting the analysis towards free riding incentives and focus on conflict instead.[30] The local harvesters have no incentives for poaching, since they only take the minimum subsistence amount, while the large extractive industry purchases its harvesting rights from the government. Resource overexploitation by extractive companies is often sanctioned by successive opportunistic officials, thus the briber becomes practically immune to expropriation due to the complicity of the regulator. Under these conditions, it can be assumed that the agents are forward-looking and solve an optimal control problem.

Condition (C_1) above amounts to maximizing $G(W, B) = W + \beta B$, where W is the aggregate welfare, B is the bribe and $(\beta - 1)$ a measure of corruption. The weight attached to the bribe entering government's utility function is higher than unity $\beta > 1$ when the government is corrupt, since it values a unit of income in its hands more than when in the hands of the public. The government's problem is then the following:

$$\underset{Q}{Max} \quad \int_0^\infty e^{-\delta t}[\pi(p, S, Q) - B(Q) + \beta B(Q) + U(S)]dt \tag{2}$$

subject to $\dot{S} = F(S) - Q - \bar{H}(S)$.

Since total firm profits are increasing in the amount harvested H on the relevant range and the bribe schedule is increasing in Q, the firm will always have an incentive to lobby

[28] See for instance Grossman and Helpman (1994), p. 839.

[29] Commercial exploitation of resources with a government-issued licence implies some system of property rights is in place.

[30] See e.g. Hotte et al. (2000) for an endogenous property rights enforcement model.

for a larger quota and the implicit constraint $H \leq Q$ holds with equality. The solution to the optimal control problem is presented in the Appendix section (2) and it yields a general decision rule of the following form:

$$(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta - 1)B_Q] - \pi_{QQ}\dot{Q} - (\beta - 1)B_{QQ}\dot{Q} - \pi_{QS}\dot{S} = \pi_S + U_S. \qquad (3)$$

Similarly, according to condition (C_2) above, the optimal harvesting quota and bribe tuple has to also maximize $\{\pi + G\}$:

$$\underset{Q}{Max} \quad \int_0^\infty e^{-\delta t}[2\pi(p, S, Q) - 2B(Q) + \beta B(Q) + U(S)]dt \qquad (4)$$

subject to $\dot{S} = F(S) - Q - \bar{H}(S)$, which is shown in the Appendix section (3) to imply:

$$(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta - 2)B_Q] - 2\pi_{QQ}\dot{Q} - (\beta - 2)B_{QQ}\dot{Q} - 2\pi_{QS}\dot{S} = 2\pi_S + U_S. \qquad (5)$$

In a steady-state equilibrium, conditions (1.3) and (1.5) above become respectively equivalent to: $(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta - 1)B_Q] = \pi_S + U_S$ and $(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta - 2)B_Q] = 2\pi_S + U_S$. Solving for the optimal 'bribing intensity' $B_Q = \frac{1}{\beta - 1}(\frac{\pi_S + U_S}{\delta - F_S + \bar{H}_S} - \pi_Q)$ from the first and substituting into the second yields the following truthful-contribution equilibrium decision rule in the steady state:

$$(F_S - \bar{H}_S) + \frac{\beta\pi_S + U_S}{\beta\pi_Q} = \delta, \qquad (6)$$

where recall that $\beta > 1$ because the government is assumed to be corrupt.[31] This expression yields implicitly the steady state stock of the resource under a corrupt government S^c. The government allows industrial harvesting to deplete the resource up to a level at which the discount rate just equals the net marginal benefit of conservation to the government, with

[31] The problem is equivalent in the steady state with one in which the government maximizes a social welfare function in which industry profits enter with a weight of β, while the aggregate utility function of the locals enters with a unitary weight.

the industry profits being assigned a higher weight than the locals' utility. Substituting the optimal exploitation rule in the bribe intensity expression above yields: $B_Q = \pi_Q - \frac{\pi_S}{\delta - F_S + \bar{H}_S}$, which is the adapted expression for local truthfulness: the gradient of the bribe schedule coincides with the marginal contribution to the lobby group's profit of the extra unit of harvesting, taking into account the stock externality of resource depletion.[32] The following intermediate results are instructive for further analysis.

Lemma 1: *Bribing intensity increases as the stock gets depleted.*

While by applying (2.6) it is easy to see that $B_Q > 0$, that is the bribe schedule increases in the quota, the bribing intensity can also be expressed as: $B_Q = \frac{U_S}{\beta} \cdot \frac{1}{\delta - F_S + \bar{H}_S}$. Then the following cross-partial derivative of the bribe schedule $B_{QS} = \frac{\beta}{(\delta - F_S + \bar{H}_S)^2}[U_{SS}(\delta - F_S + \bar{H}_S) + U_S(F_{SS} - \bar{H}_{SS})]$ is negative under the assumption of negative second partial derivatives of the resource growth and profit functions with respect to stock. In order for the regulator to respond to its policy preferences, the industrial lobby needs to keep it weakly better off than under the first best case. When the resource is more scarce, the necessary efforts by the firm to increase the harvesting quota by one unit are larger, due to the need to compensate for a sharply falling social welfare function.

Lemma 2: *A more myopic government is less conservationist.*

This result is intuitive, and the proof provided in the Appendix section (4)(i) is immediate. Higher discounting of future periods implies larger weights attached to harvesting-derived present payoffs and consequently leads to a lower steady-state resource stock level.

[32] This is, for instance, the equivalent of condition (9), p. 839 in Grossman and Helpman (1994). By contrast, a myopic industry would prefer a quota satisfying the equality between the bribing intensity $B_Q = \pi_Q$, as a result of the static maximization of their harvesting profits net of the bribe: $\Pi(p, Q) - B(Q)$. The implicit assumption is that the firm's optimal harvesting level is below the government quota, due to the government's additional objectives.

Lemma 3: *If the marginal stock effect under one resource management regime is larger than under a different one at all possible stock levels, then the equilibrium stock level in the first case is also larger than in the second, ceteris paribus.*

In short: if 1 and 2 denote different regulator objectives and $MSE_2(S) > MSE_1(S)$, for all feasible levels of stock ($\forall S \in [0, K]$), then $S_2^* > S_1^*$. A proof by contradiction is provided in the Appendix section (4)(ii) and this result facilitates the comparisons of equilibrium stock levels across the different policy environments.

Comparing the equilibrium stock level set by a self-interested government with the 'efficient' level set by an honest government, i.e. equations (2.1) and (2.6) above, yields the following result:

Proposition 1: *The steady-state equilibrium stock level when harvesting is regulated by a corrupt government is always below that obtained under an honest government.*

Proof: provided in the Appendix section (5).

The proof relies on Lemma 3 and on the fact that the corruption coefficient is larger than unity. This proposition establishes the dynamic natural resource counterpart of the Lopez and Mitra (2000) result, which states that pollution is higher in corrupt regimes, obtained in their case as a Nash bargaining outcome of a game between the government and the private firm.[33]

This finding is not as banal as it may seem, since an established result in the field of natural resource economics is that profit maximization and efficient resource conservation are not incompatible under the assumption that property rights are well-defined.[34] The optimal decision equation for a corrupt government can be re-written as: $F_S - \bar{H}_S + \frac{\pi_S + U_S}{\pi_Q} = \tilde{\delta}$, where

[33] The result also corroborates the findings in Barbier et al (2005) for the case of resource conversion, and those in Fredriksson and Svenson (2002) for environmental regulation.

[34] '...the monopolist is the conservationist's friend.' according to Solow (1974), p. 8, among others.

$\tilde{\delta} = \delta + \frac{U_S}{\pi_Q}(1 - \frac{1}{\beta})$ is above δ for all values of the corruption coefficient larger than one. The presence of corruption is equivalent to the government being more myopic in its resource policy making. Intuitively, the resource is valuable for a group to which the corrupt government is attaching a lower weight. In the first best case when the regulator is honest, the presence of small harvesters leads to an equilibrium stock that is larger than the profit-maximizing level. When the regulator is corrupt, the policy influence of locals is weakened and the second-best income transfer that takes place via the resource policy entails a lower steady-state level of stock. It is evident in the optimal decision rule formula that the opportunistic government effectively attaches a weight of $\beta > 1$ to terms related to industry profits, while the harvesters' utility is assigned a unitary coefficient. Hence, the resource outcome is unambiguously less conservationist than under an honest government.

Thus far the behavior of resident small harvesters has been restricted to each consuming passively a subsistence amount $\bar{h}$ of the resource good. Therefore, their channel of influencing the environmental outcome was, by design, limited to the inclusion of their group utility in the social welfare function.[35] In what follows, the harvesters will be in the position to exert additional influence on the government, as they can generate unrest which is costly for the government.

2.2. Internal Pressure: the Shadow of Conflict

Assume now that the locals have the option of manifesting their discontent by civil unrest or starting an insurgency.[36] The trade-off for the government is between allowing for more

[35] The above harvesters only count as voters, which is the reason why even a corrupt government takes their concerns into account when devising the resource management policy, or alternatively they could 'vote with their feet' by migrating.

[36] This situation can result from small harvesters resolving their collective action problem. Using the language of Acemoglu and Robinson (2005), the small harvesters have *de facto* political power in this setting.

resource depletion in exchange for monetary contributions from the industry and augmenting the discontent of the locals.

There are two features of the present view of conflict that should be mentioned here. First, civil tensions are modeled in the paper not as a discontinuity in the government's utility profile, but rather as a process that can be tolerated by a corrupt government as 'a cost of doing business'. This allows one to look at the interplay between the threat of conflict and policy outcomes, when one interest group is not organized as a lobby, but rather as 'rebels'. The specter of conflict becomes relevant not due to direct appropriation of the resource, but rather via policy channels, through the higher-than-optimal harvesting quota set by the corrupt government. Unlike other papers in the literature[37] which assume perfectly myopic agents that deplete the resource up to a conflict-generating threshold, in this paper corruption is the actual trigger of conflict. Consequently, the issue becomes one of the *degree* of civil unrest, where all-out civil war erupts when violence reaches a certain level, which may or may not be known by the government. This is consistent with the empirical analysis in the second chapter, where conflict is defined in relation with a certain 'battle-related deaths'-threshold. This will be modeled here as an expected cost of conflict exceeding an arbitrary threshold.

A second distinguishing feature of conflict as modeled here is that it is asymmetric. Most theoretical models of conflict feature two parties facing symmetric problems of allocating scarce resources - usually labour, bounded by population sizes - between productive and bellicose uses. However, in episodes of resource-based violence it is far more common to witness one group revolting against the government. Civil conflicts are defined in the leading global data collection projects as invariably involving the government.[38] The interaction between

[37] Maxwell and Reuveny (2000), Homer Dixon, Gledisch, among others.

[38] UCDP defines conflict as: 'a contested incompatibility that concerns government and/or territory where

the two parties is then asymmetrical, with the government having non-military options at its disposal to either alter the contentious resource policy in order to appease the potential rebels, or to deter them by investing in the military and thus avoid an all-out conflict.

The discontent of the locals vis-à-vis the government-sanctioned exploitation of resources as modeled here corresponds to 'frustration-aggression' theories based on relative deprivation: violence arises as a result of a discrepancy between actual payoff and perceived merit.[39] Small harvesters' maximum potential payoff corresponding to the case when they rebel and win a conflict against the government is what they obtain when they actually set the harvesting policy themselves. It is reasonable to assume here they prefer zero industrial harvesting, given that there are no employment and income spillovers from the industrial harvester of the resource. The stylized fact that the local populations hardly ever draw any benefits from industrial resource extraction is confirmed by ample case-study evidence, and is mostly based on widespread use of capital-intensive exploitation technology and of a relatively skilled migrant workforce.[40]

Therefore, the ideal payoff of peasant harvesters is $U^* = U(S^*)$, where S^* denotes the 'pristine' state of the resource where the only extraction is done by subsistence harvesters, or S^* solves $F(S) = \bar{H}(S)$.[41] The propensity to rebel ρ is defined as a function of the stock-related *objective discontent* of the local peasants, measured as $\Delta U = U^* - U$. The likelihood

the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths.' See http: //www.prio.no/cwp/armedconflict/current/Codebook_v4−2006b.pdf for more details.

[39] For a thorough exposition of these concepts in the context of resource conflicts see Homer-Dixon (1999), p. 136.

[40] See Renner (2002), p. 40.

[41] Alternatively, the ideal stock level could equal the long-run optimum as regulated by an honest government.

of social unrest depends on the resource-related motivation of the locals and it is represented by the following function defined on the continuous domain between zero and one:

$$\rho(S) = \frac{U^* - U}{\Delta U + U} = \frac{\Delta U}{U^*}.$$

Using the aggregate utility function defined before, $\rho = \frac{1}{U^*}[\bar{h}(\frac{1}{S} - \frac{1}{S^*}) + \bar{h}(\frac{\ln\frac{\bar{q}S}{w}}{S} - \frac{\ln\frac{\bar{q}S^*}{w}}{S^*})]$ and $\rho_S = \frac{-1}{U^*}\frac{\bar{h}}{S^2}\ln\frac{\bar{q}S}{w}$. Consequently $\rho_S = -\frac{U_S}{U^*} < 0$, so unrest is more likely as the resource gets more depleted. Appeasing or deterring unrest is costly. Assume that the government's utility drop induced by the locals' discontent is an increasing function of the size of the peasant population L: $C(L(S,w)) = \gamma L(S,w) = \gamma(\bar{q} - \frac{w}{S})$, with γ a parameter: the cost of dealing with insurgents is proportional to their number. This is in fact assuming the simplest constant return to scale technology of conflict.

Maximizing the government utility under these circumstances entails taking into account the costs of civil unrest:

$$(C_1^w)\ \underset{Q}{Max} \quad \int_0^\infty e^{-\delta t}[\pi(p,S,Q) - B(Q) + \beta B(Q) + U(S) - \rho(S)C(L(S,w))]dt$$

while maximizing the joint industry-government payoffs is equivalent to:

$$(C_2^w)\ \underset{Q}{Max} \quad \int_0^\infty e^{-\delta t}[2\pi(p,S,Q) - 2B(Q) + \beta B(Q) + U(S) - \rho(S)C(L(S,w))]dt,$$

subject to the familiar resource constraint.

The solutions to the two problems are given in the Appendix section (6) and in a steady-state equilibrium the following obtain:

$(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta-1)B_Q] = \pi_S + U_S - \rho_S C - \rho C_L L_S$ and $(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta-2)B_Q] = 2\pi_S + U_S - \rho_S C - \rho C_L L_S$.

Expressing the 'bribing intensity' as $B_Q = \frac{1}{\beta-1}(\frac{\pi_S + U_S - \rho_S C - \rho C_L L_S}{\delta - F_S + \bar{H}_S} - \pi_Q)$ from the first equation and substituting into the second yields the modified augmented golden rule of renewable resource exploitation under a corrupt government when conflict is possible as:

$$(F_S - \bar{H}_S) + \frac{\beta\pi_S + U_S - \rho_S C - \rho C_L L_S}{\beta\pi_Q} = \delta. \tag{7}$$

There are two opposite effects induced by the discontent-fueled unrest. On one hand, the cost of keeping unrest under control induces the government to effectively regulate a higher level of the resource stock, while on the other hand it has an incentive to draw the resource level further down, since this weakens the local (potential rebel) workforce, thus decreasing the cost of discontent. The net effect of allowing for the possibility that the locals may manifest their 'grievance' in a costly way for the government depends on the relative strength of the *discontent* and *migration* effects.

Comparing the resource stock implied by equation (1.7) with the one in (1.6) yields the following: When the relative increase in discontent caused by a unit decrease in the level of resource stock exceeds the corresponding cost savings brought about by migration, so that the net effect of depletion entails a positive cost to the government or: $-\rho_S C - \rho C_L L_S > 0$, the marginal stock effect with conflict is higher than its no-violence counterpart. The intuition is the following: when local harvesters pose a credible challenge by making it costly for the government to opportunistically deplete the resource, their implicit policy weight increases. The ensuing regulation is then bound to be more conservationist.

Proposition 2: *The specter of conflict based on resource-related discontent of local harvesters under a corrupt government has conservationist consequences when the 'discontent' effect dominates, i.e. for a low ideal stock level (S^*) and low outside opportunities (w) and high maximum harvesting ability $\bar{q}$. The equilibrium stock decreases if the 'migration' effect dominates, for opposite values of the parameters.*

Proof: provided in the Appendix section (7) and below.

The Appendix section (7) shows the condition under which costly discontent increases the equilibrium level of the resource stock takes the following form: $G(S) = \theta S + (\frac{\bar{q}S}{w} - 2)lnS - \phi >$

0, where $\theta = (\frac{\bar{q}}{w}\ln\frac{\bar{q}}{w}+\varepsilon)$, $\phi = 2\ln\frac{\bar{q}}{w}-1$ and $\varepsilon = \frac{\ln\frac{\bar{q}S^*}{w}+1}{S^*}$. While an analytical solution cannot be obtained, the graph in Figure 1.1 shows - via a numerical simulation - that satisfying the inequality entails that the steady-state optimal stock level exceeds a certain threshold level S'.[42] The discontent effect curve shifts up when $\bar{q}$ is higher and when w is lower.[43] The migration effect shifts down when w and S^* are lower.[44] Thus, it can be seen that the threshold value S' is lower, thus easier to fulfill for higher θ, implying higher $\bar{q}$ and lower w, as well as for higher ε, which entails a lower S^*, since $\frac{\ln S^*}{S^*}$ decreases in S^*.

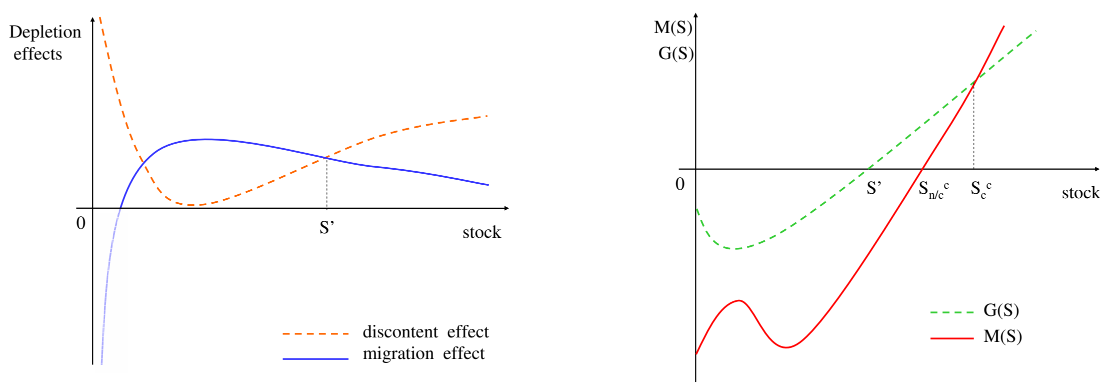

Figure 1: Discontent and Migration Effects

According to (1.6), the optimal stock level without conflict is given by $M(S) = (\delta - F_S + \bar{H}_S)\beta\pi_Q - \beta\pi_S + U_S = 0$, while the optimal stock with conflict arises at the intersection of

[42] Notice that both functions in the first graph are constrained to be positive here.

[43] The 'discontent effect' curve plotted is $-\rho_S C(L(S,w))$ and its non-monotonicity in S is driven by the fact that the marginal propensity to rebel is decreasing in S, while the cost of dealing with the rebellion is increasing in the number of locals, which in turn is increasing in S.

[44] This effect is also non-monotonic, since the propensity to rebel is decreasing in S, while the marginal cost is increasing in S.

$M(S)$ and $G(S)$, as shown in the second graph.[45] The condition that the equilibrium stock level is 'large enough' is also more likely for a higher $S^c_{n/c}$, which entails that the corruption coefficient β, the ratio $\frac{r}{K}$ and the price of the resource good p are all low.

If the migration effect exceeds the discontent effect, the marginal stock effect and the equilibrium stock are smaller when conflict is possible. In this case the government has an incentive to purposefully deplete the resource in order to drive out the potentially inconvenient locals. This occurs when the ideal stock level and outside opportunities are high and/or when the local harvesters have a high harvesting ability. Under full information, harvesters would consequently have less of an incentive to organize and mount pressure on the government, knowing the result would be an acceleration of resource depletion and implicitly a decrease of their utility.

Comparing the marginal stock effect implied from (1.7) to the one obtainable under an honest government (1.1) opens the somewhat surprising possibility that:

Corollary 1: *Under the specter of corruption-triggered conflict, an opportunistic government can be even more conservationist than the honest government.*[46]

This may occur when the government is not 'too corrupt' relative to parameters: $\beta < 1 - \frac{\rho_S C + \rho C_L L_S}{U_S}$, which after plugging in the functional forms introduced above is equivalent to $\beta - 1 < \frac{\gamma}{h}$. Such a situation is facilitated when a high marginal cost of waging war for the government combines with a not too large subsistence amount and relatively low corruption to yield a more conservationist policy outcome.

An important motivation of this paper has been to understand the effect of resource policy

[45] The simulation is based on logistic resource growth with intrinsic growth rate r and carrying capacity K: $F(S) = rS(1 - \frac{S}{K})$ and the simplest industry profit function $\pi(p, Q, S) = (p - \frac{c}{S})Q$.

[46] This result assumes conflict is only possible when the government is opportunistic, or $S^* = S^h$ emphasizing the 'grievance' aspect of this rebellion: insurgency is legitimate only against a corrupt government.

and governance quality on resource-based civil conflicts. Here the focus is on the effect of corruption on the likelihood of conflict, given 'official corruption' as related to the exploitation of natural resources is one of the main justifications of such rebellions. As mentioned above, civil unrest is called a civil *conflict* when a certain intensity of violence is reached. This is represented here by the expected cost of conflict, denoted by $P(S) = \rho(S)C(L(S,w))$. The larger P, the more likely it is that a discontent-motivated civil conflict will occur in this setting. Differentiating this function with respect to the stock level of the contentious resource S, the following obtains:

$$P_S = \rho_S C + \rho C_L L_S.$$

While the locals' discontent increases as the level of stock goes down, the requirements of subsistence consumption fosters emigration and weakens the rebellion threat, such that the probability of conflict increases in corruption for some levels of the resource stock and it decreases in corruption for others. In this setting *discontent-driven grievance-based resource conflict* arises when $P_S < 0$, or when:

$$-\rho_S C > \rho C_S. \tag{8}$$

While (1.8) is an implicit relationship, it has an intuitive interpretation. When the increase in discontent brought about by a one-unit decrease in stock level is more than the marginal cost savings associated with the outward migration of potential rebels, the resulting likelihood of conflict increases, situation which is more likely when the equilibrium resource level is sufficiently high, which in turn requires parameters to be as described in Proposition 2. The opposite occurs when the migration effect dominates, as the government may be more able to keep the civil unrest under control and prevent it from erupting into a full-blown conflict.

As the corruption coefficient only influences the probability of conflict via the regulated level of depletion,[47] its partial effect can be written as:

$P_\beta = (\rho_S C + \rho C_L L_S) S_\beta = P_S S_\beta$.

When the discontent effect dominates, corruption increases the likelihood of conflict, since $P_S < 0$ and $S_\beta < 0$.[48] When the migration effect dominates, the impact of corruption of the likelihood of conflict is unclear, since $P_S > 0$, but the sign of S_β is ambiguous.

To analyze the manner in which the quality of governance affects this marginal effect of depletion on the likelihood of resource-based civil conflicts, take the cross-partial derivative of P with respect to the corruption coefficient β:

$$P_{S\beta} = (\rho_{SS} C + 2\rho_S C_L L_S + \rho C_L L_{SS} - \theta_{SS}) S_\beta. \tag{9}$$

Since when the discontent effect exceeds the migration effect the equilibrium level of the resource stock is decreasing with the regulator corruption ($S_\beta < 0$), the impact of corruption on the marginal effect of depletion on the likelihood of conflict is a function of the sign of the bracketed expression in (2.9) which equals P_{SS}. Appendix section (9) shows that $P_{SS} > 0$ when the equilibrium level of stock exceeds S'', condition which is more restrictive than the one stipulated in Proposition 2 above, yet is also more likely to be satisfied for high $\bar{q}$ and low w and S^*, as well as low β, p and $\frac{r}{K}$. Under such conditions, case in which $S_\beta < 0$, the result that $P_{S\beta} < 0$ obtains. In words:

Corollary 2: *The marginal effect of depletion on the likelihood of conflict can decrease with corruption as long as harvesting ability and carrying capacity of the environment are low, outside opportunities, ideal stock level, governmental corruption, price of the product and intrinsic growth rate of the resource are high.*

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[47] Alternatively, one can imagine the quality of governance entering directly into a discontent function for the local harvesters, although this would entail measurement issues related to the difference between real and perceived levels of corruption.

[48] See the Appendix section (8) for the derivation.

This may help understand why the more corrupt places are not always the ones witnessing episodes of resource-based civil conflict, even though 'governmental corruption' ranks high in the motivation list of insurgents.

2.3. External Pressure: Trade and Aid

Despite their name, resource-based civil conflicts, are rarely purely 'domestic',[49] but rather depend on international trade, finance and aid networks. In the present model this international dimension is represented by the possibility of trade measures against the regime and of international transfers or aid.

The optimal harvesting expression under a corrupt government under the threat of conflict presented in (2.7) allows for a few comparative statics that shed light on the impact of international pressure on the quality of the domestic resource extraction regime. In particular, the effect of trade sanctions and international aid, which are often the measures of choice to achieve such purposes can be readily derived. In peace time, the large scale industry exports the good. Assume, as it is common in the literature,[50] that the effect of *international sanctions* against a regime that overexploits the environment is to reduce instantaneously the producer price from commercializing the resource good. Then, the sole effect of the resource-related sanctions here is to decrease the profits of the firms π. Sanctions can be modeled as an ad-valorem import tariff for the resource good (τ), that can be varied from zero to infinity, to increase the severity of the restriction. Then profits can be written as $\pi(p', S, H)$, where $p' = p(1-\tau)$.[51] The goal of the sanctions is then reached if the long-run equilibrium level of

[49] Le Billon (2000), points to globalization as responsible for the increased duration of such conflicts, due largely to easier financing, arms trade and trade in illicit resources (p. 3).

[50] See, for instance, Damania and Barbier (2001).

[51] Note that, absent a domestic market for the resource good, an equivalent effect is observed when there is a negative shock to the international price of the resource, or a hike in the extraction costs due, perhaps,

the resource stock is higher as a result of their imposition. The following holds:

Proposition 3: *A drop in profits caused by resource-targeted international trade sanctions will, ceteris paribus, have a conservationist effect on the resource as long as the the conditions for $P_{SS} > 0$ are satisfied.*

Proof: see below and in the Appendix section (10).

Differentiating expression (2.6) implicitly with respect to the price of the resource export p yields, upon further transformation:

$$\frac{\partial S}{\partial p} = \tag{10}$$

$$\frac{(\delta - F_S + \bar{H}_S)\beta\pi_{QS} - \beta\pi_{sp}}{\beta\pi_Q(F_{SS} - \bar{H}_{SS}) + \beta\pi_{SS} + U_{SS} - \rho_{SS}C - 2\rho_S C_L L_S - \rho C_L L_{SS} - (\delta - F_S + \bar{H}_S)\beta\pi_{QS}}.$$

As discussed in the Appendix section (10), the denominator is negative if $P_{SS} > 0$ equivalent to $S > S''$, due to the concavity of the utility, profit and resource growth functions. In addition, notice that when marginal profit is independent of the price ($\pi_{sp} = 0$), the numerator is positive, and therefore, the equilibrium stock level is decreasing with price. The last assumption holds for the family of profit functions for which harvesting costs are not a function of price and harvested quantity is independent of the stock. The same result holds, nevertheless, when, $\pi_{sp} \neq 0$[52] but $\frac{\pi_{Qp}}{\pi_Q}(\beta\pi_S + U_S) > \beta\pi_{sp}$, where the latter inequality is shown in the Appendix section (10) to hold whenever $P_S < 0$, or $S > S'$.[53]

In this case, sanctions work to conserve the resource if they result in effective producer price reductions. Intuitively, sanctions increase the attractiveness of 'investing' in the resource

to an increase in the price of an essential input.

[52] In the present case the harvested amount depends on the stock level since it is equal to the regulated TAC which is determined as the argument the maximizes the social welfare function and the joint regulator-client surplus.

[53] Except for peculiar specifications where production costs depend on final good prices.

stock by lowering the opportunity cost of conservation. In the political game, lower unit profits translate - since the optimal bribe is truthfully reflecting the marginal effect of increased quota on profits - into lower bribes, thus inducing the regulation of lower harvesting quotas, and has an effect similar to a decrease in corruption. In short, sanctions lower the attractiveness of the prize in the lobbying game. This finding extends to this particular political-economy framework the established result that in a one-species setting and where an independent habitat value is not considered, international sanctions work to increase the long-run stock of the resource.[54] As emphasized in the literature on the conservationist effect of international trade measures, ambiguous or perverse resource stock effects are only obtained when sanctions effectively change the management regime to one of open access, or when the resource becomes a nuisance as an effect of sanctions and the more profitable alternative use of its habitat renders over-depletion or even extinction optimal.

International aid conditional on implementing a certain type of resource management is another possible way to externally influence a country's resource extraction policy.[55] Recently, the global warming debate has fostered the emergence of many such new initiatives which provide grants in return for conservation.[56] While unconditional transfers might have adverse rent-seeking effects on the host economy characteristic to revenue booms, conditional aid may

[54] This result appears, for instance, in Schulz (1996) and Barbier and Schulz (1997) and is contrary to a series of papers by Swanson (1993), which claim sanctions are an ineffective policy.

[55] Examples are: the Global Environmental Facility (GEF), which provides grants for nature protection, and *debt-for-nature swaps*, whereby a conservationist agency and/or creditors of a (usually) developing country agree to sponsor conservationist policies. See also Damania and Barbier (2001), p. 16.

[56] A 2007 initiative titled 'Leaving Ecuador's Oil in the Ground,' seeks to attract international funding to avoid carbon emissions and save the Yasuni Rainforest where '[at] least two indigenous tribes, the Tagaeri and Taromenane, maintain their traditional lifestyles in voluntary isolation', according to the World Resources Institute. See http://www.wri.org/.

be successful in effecting positive change. Provided monitoring capabilities exist, the transfer could be granted conditional on the level of the resource stock (T(S) with $T_S > 0$). Given the fact that the regime is corrupt, it can be assumed - based on case study evidence - that only a part of the international transfer reaches its intended target. In other words, suppose the government embezzles a fraction α of this aid. For simplification, if $\alpha < 1$, the rest of the transfer is supposedly destined for a payoff-neutral use, for instance to pay off a part of the country's foreign debt.[57]

$$(C_1^T)\ \underset{Q}{Max} \quad \int_0^\infty e^{-\delta t}[\pi(p,S,Q) - B(Q) + \beta[B(Q) + \alpha T(S)] + U(S) - P(S)]dt$$

subject to $\dot{S} = F(S) - Q - \bar{H}(S)$, where recall that $P(S) = \rho(S)C(L(S,w))$, and $P_S = \rho_S C + \rho C_L L_S$.

The truthful contribution and quota also solve:

$$(C_2^T)\ \underset{Q}{Max} \quad \int_0^\infty e^{-\delta t}[2\pi(p,S,Q) - 2B(Q) + \beta[B(Q) + \alpha T(S)] + U(S) - P(S)]dt$$

subject to $\dot{S} = F(S) - Q - \bar{H}(S)$.

The solution to this optimization problem is given in the Appendix section (11) which provides the optimal exploitation condition in the presence of resource management - targeted international aid:

$$(F_S - \bar{H}_S) + \frac{\beta\pi_S + U_S + \alpha\beta T_S - P_S}{\beta\pi_H} = \delta. \tag{11}$$

Again, the marginal stock effect is unambiguously increased by the transfer, since $T_S > 0$ and $\beta > 1$, and so the transfer attains its conservationist goal.

Comparing this to the quota set by the corrupt government without international aid (2.6) and calculating the comparative statics yield the following:

[57] This is assumed in order to simplify the calculation. The inclusion of the remainder $(1-\alpha)T$ in the government's utility function would not change the qualitative results.

Proposition 4: *Conditional international aid leads to a higher equilibrium level of stock and the magnitude of the reduction in harvesting is proportional to the 'embezzlement' coefficient* α *(and can also increase in the corruption coefficient* β*).*

Proof: provided in the Appendix section (11).

The intuition for this result is simple. Aid directly decreases the attractiveness of resource exploitation for the government. The fact that the transfer is partly appropriated by the government means that the relative 'value of conservation' rises in the corrupt government's objective, and so the equilibrium stock level increases in the presence of aid conditional on the resource policy, with the increase being positively related to regulator corruption.[58]

It is straightforward to show that this result is not driven by particular assumptions related to the form of the international transfer. Alternatively, the transfer T can be designed as a function of the regulated harvesting: $T(Q)$ where $T_Q < 0$. The critical assumption is, again, that the international donors have some monitoring capabilities in place for the resource policies set by the government: the quota Q is either directly observable or can be inferred from the industry's financial statements. The government manages to embezzle a fraction α of the transfer and solves the following problem:[59]

$$(C_1^T)' \underset{Q}{Max} \int_0^\infty e^{-\delta t}[\pi(p,S,Q) - B(Q) + \beta[B(Q) + \alpha T(Q)] + U(S) - P(S)]dt$$

subject to $\dot{S} = F(S) - Q - \bar{H}(S)$.

The truthful contribution and quota also solve:

$$(C_2^T)' \underset{Q}{Max} \int_0^\infty e^{-\delta t}[2\pi(p,S,Q) - 2B(Q) + \beta[B(Q) + \alpha T(Q)] + U(S) - P(S)]dt$$

[58] Barbier and Schultz (1997) obtain a similar result in a setting where they consider habitat conversion (p. 161).

[59] The rest of the transfer has no further redistributive repercussions, as it is mandated to go towards a public good destination, e.g. re-paying the country's external debt.

subject to $\dot{S} = F(S) - Q - \bar{H}(S)$ and the truthful resource exploitation policy rule satisfies the following relation, as the Appendix section (11) further details:

$$(F_S - \bar{H}_S) + \frac{\beta\pi_S + U_S - P_S}{\beta\pi_Q + \alpha\beta T_Q} = \delta,$$

where $T_Q < 0$ and the marginal stock effect is again increased by the presence of the conditional aid. As long as both trade sanctions and international aid increase the equilibrium level of the resource stock, they contribute to a decreased equilibrium likelihood of conflict.

2.4. Evidence

Civil wars may have their origin in several different social phenomena. Only one potential source of resource-based conflicts is investigated here, namely discontent-driven rebellion. The following refines the investigation of a 'grievance' based motive for internal violence. Previously, the proxies used for grievances were broad and political-based: level of democracy and measures of ethnic and religious fractionalization. Given the relatively large number of what appear to be resource-based conflicts out of the total civil conflicts, an additional way one can think about resource exploitation and the quality of the governance as factors leading a certain group to consider conflict was suggested above.

Motivated by the theoretical model, the interest here is to take a first pass at exploring the relationship between the incidence of internal violence, resource depletion and quality of governance. We use a wide cross section of countries (over one hundred in most specifications) during 21 recent years. This choice of framework is motivated by the intention to have comparability with the received literature. One must be cautious, however, when interpreting the results of such large cross-section exercises, especially when the variable of interest - conflict emergence - can have a multitude of potential causes. The only correlates of civil war that are consistently robust in the empirical literature are income per capita or growth - displaying a negative relationship - and population levels - having a positive relationship - with both the onset and the incidence of domestic violence. The opportunity cost of participating in an armed insurgency is higher in a high average-income country, while a larger population per se may increase the likelihood that one particular group may rebel against the government, in a territorial dispute or in a coup. Beyond these two factors, however, there is little agreement in the field. One chief reason for this may have been that the body of theoretical literature to guide such empirical explorations is relatively slim.

We follow the empirical literature on resources and civil conflicts in exploring the determinants of civil conflict in a large panel dataset. The natural resource data comes from the World Bank's Adjusted Net Savings database, which in general provide measures of economic sustainability. [60] Following our model, a narrow focus lies primarily in the renewable resources information, such as net forest depletion.[61] The civil conflict data was obtained from the PRIO/Uppsala Armed Conflict Dataset[62] which - compared to previous sources - extends the set of conflicts by lowering the casualty threshold necessary for an episode of violence to qualify as a conflict from 1000, in the Correlates of War (C.O.W) project,[63] to 25-battle related deaths annually. Many conflicts based on local grievances of peasants are small in magnitude. Moreover, typically casualties are limited in the first year of most civil insurgencies. Appropriately for our focus, these data are much more inclusive, capturing significantly *more* than just the major civil conflicts worldwide, over the period 1946-2005.

[60] Net forest depletion calculation is based of estimated depletion rents, 'calculated as the rent on that amount of extraction which exceeded the natural increment in wood volume.' More information is provided in the World Bank manual at: http://siteresources.worldbank.org/INTEEI/1105643-1115814965717/20486606/Savingsmanual2002.pdf

[61] Unfortunately, no similar data exist for fish or wildlife.

[62] See Gleditsch et al 2002.

[63] Started by Singer and Small (1972), at the University of Michigan, and transferred to Penn State in 2001.

The operational definition of conflict used in the database is 'a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths.'[64] The dataset also includes inter-state conflicts, however, in accordance to the stated interest, only the internal ones are kept.[65] While most of the previous empirical studies use the much more restrictive 1000 casualties per year threshold, the position expressed here is the following: whereas that body of work looks actually to identify the factors important in reaching that specific intensity of hostilities, this data allows to test more directly for determinants of civil conflict *emergence*. Moreover, this higher inclusiveness is important for the identification strategy, as explained a little further.

Reliable data about corruption and the general quality of governance are difficult to collect, due to the very nature of the phenomenon, premised on concealing its existence. Therefore all data sources available for a wide array of countries and time periods are not based on factual data, but rather on perceptions.[66] These perception-based corruption indicators are constructed with information from multiple sources, and so there are less chances of any systematic bias or measurement error. The source for corruption data used here is the International Country Risk Guide (ICRG) score,[67] which refers specifically to corruption in

[64] See *UCDP/PRIO Armed Conflict Dataset Codebook*, p. 4.

[65] Categories 3 and 4, for 'internal armed conflict' and 'internationalized internal armed conflict', the latter group including civil wars that witness some form of external interference.

[66] Several studies analyze the distance between perception indicators and more factual-based measures of corruption. See Olken (2006) for a recent example, where a local measure of corruption in road-building in Indonesia is compared with corruption perceptions. Though interesting, this is not a significant problem in the present setting, where *perceived* mismanagement and embezzlement of public funds can equally generate revolt.

[67] International Country Risk Guide (Table 3B), C The PRS Group, Inc., 1984-Present. For more details see *http://www.prsgroup.com.*

the political system and to ties between business and politics. In particular, the measure of corruption refers to 'financial corruption in the form of demands for special payments and bribes...and suspiciously close ties between politics and business'.[68]

Figure 2: Civil conflict incidence and measures of fractionalization

Variables	*Dependent variable: inconflict5*			
	(1)PanelProbit	*(2)PanelProbit* *ethnic*	*(3)PanelProbit* *language*	*(4)PanelProbit* *religious*
Gdp growth (lag)	-0.035***	-0.036***	-0.040***	-0.034***
	(0.011)	(0.011)	(0.012)	(0.011)
Population (ln,lag)	0.830***	0.996***	0.951***	0.837***
	(0.252)	(0.291)	(0.278)	(0.303)
Corruption control (lag)	-0.437***	-0.423***	-0.395***	-0.438***
	(0.090)	(0.091)	(0.093)	(0.090)
Net Forrest Depletion (lag)	-0.267	-0.300	-0.275	-0.247
	(0.198)	(0.193)	(0.194)	(0.219)
Corruption*Depletion (lag)	0.136**	0.130**	0.120*	0.137**
	(0.061)	(0.062)	(0.062)	(0.062)
Polity (lag)	0.006	0.010	0.014	0.004
	(0.015)	(0.015)	(0.016)	(0.015)
Year	-0.126***	-0.129***	-0.131***	-0.125***
	(0.013)	(0.013)	(0.014)	(0.013)
Ethnic fractionalization		4.816***		
		(1.290)		
Language fractionalization			5.374***	
			(1.323)	
Religious fractionalization				-2.253*
				(1.251)
Constant	245.405***	247.813***	253.637***	245.066***
	(24.666)	(25.313)	(26.408)	(25.057)
Observations	2289	2275	2248	2289
Groups	124	123	122	124

Note: Standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Additional controls such as GDP levels and growth rates and population come from World Bank's Development Indicators. Data from the POLITY IV project were used to account for the general level of democracy in a country in the form of a special variable (`polity2`) designed specifically for time-series analyses.[69]

[68] Citation from the ICRG codebook *A Business Guide to Political Risk for International Decisions*, p. 31.

[69] For a thorough explanation of why a modification of the combined polity score is necessary, please refer to the original source: Marshall and Jaggers, *Polity IV Project: Data User's Manual* at

Since our sample includes all civil conflicts indiscriminately, it is necessary to control for other potential motivations. Artificially drawn post-colonial borders are thought to favour ethnic and territorial disputes, especially in Africa. Consequently, the database was updated with three measures of fractionalization taken from Alesina et al.(2003), referring to ethnic, language and religious dimensions.[70] Fractionalization is interpreted as the probability that two randomly chosen individuals belong to different ethnic, linguistic or religious group. Note that these are time-invariant measures (at least for our time horizon) and therefore suggest the use of the random effects model.

The dependent variable is civil conflict incidence and the model is random effects probit. Our baseline specification in the first column of the table includes lagged growth rate of GDP, population level, control of corruption, net forrest depletion, the level of democracy, as well as year dummies. Apart from corruption and depletion, these are regressors routinely used in the literature. While measures of linguistic and ethnic fractionalization are strong determinants of conflict, the interaction term between corruption and depletion is also quite robust and significant at 5 or 10%. When we calculate the marginal effects, they have the expected signs: the marginal effect of forest depletion on the incidence of civil conflicts is positive and the marginal effect of corruption control on the incidence of civil conflicts is negative. Moreover, it appears that perceived corruption's influence on the likelihood of civil conflict depends on the level of resource depletion. Not only is the interaction term significant, it also

www.cidcm.umd.edu/inscr/polity.

[70] i.e. Fractionalization equals 1 minus the respective group Herfindahl concentration index. See Alesina et al. (2003), p. 159.

has the expected sign: corruption leads to less conflict in more depleted environments. This admittedly crude exercise is expanded and developed in a companion paper which refines the empirical investigation of a grievance determinant of resource-based civil conflicts and addresses the potential endogeneity problems. We briefly note here that since we focus on the interaction between corruption and depletion,which is equivalent to a difference-in-differences approach,[71] the potential endogeneity problem of (lagged) corruption on (future) conflict is mitigated to a certain extent. It appears that these data do provide some support for attempts to extend the salient determinants of civil conflict beyond those suggested by the predominant 'greed' paradigm. The channel suggested here is by endogenizing the economic policy-making process of the government.

3. Conclusions

Natural resources can be a powerful motivator of social and political change. The issue of resource-based civil conflicts is a growing topic in both political science and economic literatures, and it has so far been approached from various angles. This paper looks at the effect of official corruption on the exploitation of renewable resources and then on the likelihood for the emergence of conflict. The study builds on the Grossman and Helpman (1994) model and looks at a dynamic externality in the form of renewable resource harvesting and three economic actors: the opportunistic government, the resource corporations that are in a position to influence the harvesting quota by bribing the regulator, and the peasant harvesters that live off the resource.

For tractability reasons, the analysis focuses on the steady-state equilibrium. It is shown in a framework where conflict is not a factor, that the opportunistic government is less conserva-

[71] We effectively ask what is the differential impact of corruption control depending on various levels of resource depletion. A similar approach can be found for instance in Collier and Hoeffler (2009), p. 302.

tionist than an honest one. Resource depletion sanctioned by an opportunistic government on one hand increases locals' discontent and the government's appeasement or deterrence costs. On the other hand, in conjunction with the outside opportunities, depletion may weaken the peasant (and potential rebel) workforce. The shadow of conflict can be conservationist when the first effect dominates, by increasing the implicit political influence of the small harvesters. The probability of resource-based conflict may increase or decrease, according to the discontent effect and the migration effect, which in turn depend on the parameters of the system. International sanctions aimed at improving the domestic environmental performance and which result in decreasing firms' profits are shown to work under reasonable conditions, while the effectiveness of environmentally-targeted international aid may depend on corruption in a counter-intuitive way.

It is then argued that the relationship between governmental corruption, the environmental outcome, and the political outcome is complex. Moreover, without positing specific functional forms that put a dent in generality, this issue is primarily empirical. The main hypotheses put forth are that a higher population level and lower outside opportunities increase the chances for violence and that while depletion increases the probability of conflict in 'not too depleted environments', the marginal effect of depletion on the likelihood of resource-based conflict may decrease in corruption. We find preliminary confirmation of this relationship using a global panel dataset including most countries over twenty recent years. These implications are further explored empirically in a companion paper.

APPENDIX:

(1). The current value Hamiltonian for the honest government's problem can be written as:

$\mathcal{H} = \pi(p,S,Q) + U(S) + \mu[F(S) - Q - \bar{H}(S)]$ and the first order conditions are the following:

$\frac{d\mathcal{H}}{dQ} = \pi_Q - \mu.$

Notice that for specific profit functions that are multiplicatively separable in Q and take the form $\Pi(p,S)Q$ this condition does not depend on the control variable, and so the solution is reached by taking the most rapid approach path (MRAP) as follows: if $\frac{d\mathcal{H}}{dQ} > 0$ by setting harvesting at the maximum level $Q = Q_{max}$, where Q_{max} is the exploitation resulting from employing the maximum effort available (bounded perhaps by the available industry labour force and/or technological parameters), while if $\frac{d\mathcal{H}}{dQ} < 0$ by setting harvesting at the minimum level $Q = Q_{min}$ (which can be zero or the break-even point for the firms). This is allowed until the shadow price of the resource μ respectively increases or decreases to equal the unit profit. The other optimality relations are derived from:

$\frac{d\mathcal{H}}{dS} = \delta\mu - \dot{\mu} = \pi_S + U_S + \mu(F_S - \bar{H}_S)$

$\frac{d\mathcal{H}}{d\mu} = \dot{S} = F(S) - H - \bar{H}(S).$

while the following transversality condition has to hold:

$\lim_{t\to\infty} \ e^{-\delta t}\mu(t)S(t) = 0.$

Imposing the conditions of zero-growth of the state and co-state variables in a steady-state equilibrium and assuming the transversality condition holds, we obtain:

$(F_S - \bar{H}_S) + \frac{\pi_S + U_S}{\pi_Q} = \delta.$

To determine the transitional path dynamics, take time-derivative of the first condition to obtain: $\dot{\mu} = \pi_{QQ}\dot{Q} + \pi_{QS}\dot{S}$ which can be substituted into the second condition as follows: $(\delta - F_S - \bar{H}_S)\pi_Q - \pi_{QQ}\dot{Q} - \pi_{QS}[F(S) - Q - \bar{H}(S)] = \pi_S + U_S$. The $\dot{H} = 0$ locus can then be determined as:

$$H = \underbrace{\frac{\pi_S + U_S - (\delta - F_S - \bar{H}_S)\pi_Q}{\pi_{QS}}} + (F(S) - \bar{H}(S)),$$ where the sign of its slope ($\frac{dH}{dS}|_{\dot{H}=0}$) is ambiguous.

Notice that setting the numerator of the fraction to zero, which is our golden rule above, is equivalent to imposing the steady-state harvesting condition. Transitional harvesting is decreasing towards the steady-state value when the fraction (its numerator) is positive, and increasing when it is negative.

(2). The current value Hamiltonian of the corrupt government's problem can be written as:

$\mathcal{H} = \pi(p, S, Q) + (\beta - 1)B(Q) + U(S) + \mu[F(S) - Q - \bar{H}(S)]$.

Note, again, that the government is opportunistic for values of β above 1. According to the maximum principle, the first order conditions for an interior solution are given by:

$\frac{d\mathcal{H}}{dQ} = 0 = \pi_Q + (\beta - 1)B_Q - \mu$

$\frac{d\mathcal{H}}{dS} = \delta\mu - \dot{\mu} = \pi_S + U_S + \mu(F_S - \bar{H}_S)$

$\frac{d\mathcal{H}}{d\mu} = \dot{S} = F(S) - Q - \bar{H}(S)$, and we assume the transversality condition to hold.

Taking the time derivative in the first condition above yields: $\dot{\mu} = \pi_{QQ}\dot{Q} + (\beta - 1)B_{QQ}\dot{Q} + \pi_{QS}\dot{S}$ and plugging it into the second condition:

$$(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta - 1)B_Q] - \pi_{QQ}\dot{Q} - (\beta - 1)B_{QQ}\dot{Q} - \pi_{QS}\dot{S} = \pi_S + U_S.$$

(3). The problem of maximizing the joint industry-government payoffs is solved in a very similar fashion:

Use current value Hamiltonian $\mathcal{H} = 2\pi(p, S, Q) + (\beta - 2)B(Q) + U(S) + \lambda[F(S) - H - \bar{H}(S)]$ to get first order conditions:

$\frac{d\mathcal{H}}{dQ} = 0 = 2\pi_Q + (\beta - 2)B_Q - \lambda$

$\frac{d\mathcal{H}}{dS} = \delta\lambda - \dot{\lambda} = \pi_S + U_S + \lambda(F_S - \bar{H}_S)$

$\frac{d\mathcal{H}}{d\lambda} = \dot{S} = F(S) - Q - \bar{H}(S)$.

Together these conditions imply:

$$(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta-2)B_Q] - 2\pi_{QQ}\dot{Q} - (\beta-2)B_{QQ}\dot{Q} - 2\pi_{QS}\dot{S} = 2\pi_S + U_S.$$

(4). (i) A higher discount rate δ means that in order for equation (1.6) to hold, the equilibrium stock of the resource will adjust to a lower level, corresponding to a higher net growth rate $F_S - \bar{H}_s$ and a lower marginal stock effect (MSE), both evaluated at the optimal stock level. A more impatient corrupt government will regulate harvesting so that the resource stock settles at a lower long-run level.

(ii) To show Lemma 3, assume we have two functions of the stock of the same resource $MSE_1(S)$ and $MSE_2(S)$, where $MSE_2(S) > MSE_1(S)$, $\forall S \in [0, K]$. This is then true, in particular, for $S = S_2^* : MSE_2(S_2) > MSE_1(S_2) \quad (*)$.

We also know that the following two relations governing optimal exploitation are verified at the optimum levels of stock S_1^* and S_2^*:

$F_S(S_1^*) + MSE_1(S_1^*) = \delta$ and

$F_S(S_2^*) + MSE_2(S_2^*) = \delta$, where the resource dynamics and the discount rate are common across the two problems. Assume, by contradiction, that $S_2^* < S_1^*$. It follows that $F_S(S_1^* < F_S(S_2^*)$ and then for the above equations to hold concomitantly, we need $MSE_1(S_1^*) > MSE_2(S_2^*) \quad (**)$. Put together, the two starred relations imply that $MSE_1(S_1^*) > MSE_1(S_2^*)$, which further implies - since the functions representing the marginal stock effects under the different policy regimes are decreasing in the level of stock - that $S_2^* > S_1^*$, which is a contradiction.

(5). It is easy to see that $MSE^c_{n/c} < MSE^h_{n/c}$ (where the subscripts refer to 'no-conflict' and the superscripts to government corruption) iff $\frac{\beta\pi_S + U_S}{\beta\pi_H} < \frac{\pi_S + U_S}{\pi_H}$. This is true in all cases, given the assumption that $\beta > 1$.

Alternatively, differentiate (2.6) with respect to the corruption coefficient to obtain:

$\beta^2\pi_Q^2(F_{SS} - \bar{H}_{SS})S_\beta + S_\beta[(\beta\pi_{SS} + U_{SS})\beta\pi_Q - (\beta\pi_S + u_S)\beta\pi_{QS}] + \beta\pi_Q\pi_S - (\beta\pi_S + U_S)\pi_Q = 0,$

which implies:

$$S_\beta = \frac{U_S\pi_Q}{\beta^2\pi_Q^2(F_{SS}-\bar{H}_{SS})+(\beta\pi_{SS}+U_{SS})\beta\pi_Q-(\beta\pi_S+u_S)\beta\pi_{QS}} < 0,$$

where the inequality derives from the concavity of functions F, π and u.

(6). The current value Hamiltonian for the government utility maximization problem when conflict is possible is:

$\mathcal{H} = \pi(p,S,Q) + (\beta-1)B(Q) + U(S) - \rho(S)C(L(S,w)) + \mu[F(S) - H - \bar{H}(S)]$ and the first order conditions are:

$\frac{d\mathcal{H}}{dQ} = 0 \rightarrow \pi_Q + (\beta-1)B_Q = \mu$

$\frac{d\mathcal{H}}{dS} = \delta\mu - \dot{\mu} = \pi_S + U_S - \rho_S C - \rho C_L L_S + \mu(F_S - \bar{H}_S)$

$\frac{d\mathcal{H}}{d\mu} = \dot{S} = F(S) - H - \overline{h}.$

Take derivative with respect to time in the first condition above and plug into the second to obtain:

$(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta-1)B_Q] - [\pi_{QQ} + (\beta-1)B_{QQ}]\dot{Q} = \pi_S + U_S - \rho_S C - \rho C_L L_S$

In the steady state: $(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta-1)B_Q] = \pi_S + U_S - \rho_S C - \rho C_L L_S$ and this implies: $B_Q = \frac{1}{\beta-1}[\frac{\pi_S+U_S-\rho_S C-\rho C_L L_S}{\delta-F_S+\bar{H}_S} - \pi_Q]$.

Similarly, the joint industry-government surplus maximization yields in the steady-state:

$(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta-2)B_Q] = 2\pi_S + U_S - \rho_S C - \rho C_L L_S$.

Plug in B_Q from above to get the steady state equilibrium policy rule for renewable resource exploitation when conflict is possible: $F_S - \bar{H}_S + \frac{\beta\pi_S+U_S-\rho_S C-\rho C_L L_S}{\beta\pi_H} = \delta$.

(7). Compare this to the case without conflict and with a corrupt government in (2.6). Notice that the marginal stock effect with conflict is larger than the marginal stock effect without conflict if $-\rho_S C - \rho C_L L_S > 0$ or if $\frac{-\rho_S}{\rho} > \frac{C_L L_S}{C}$. Given the expressions for ρ, C and their derivatives with respect to stock provided in the text, this becomes equivalent to $\ln\frac{\bar{q}S}{w}(\bar{q} - \frac{w}{S}) > \frac{w}{S} - \frac{w}{S^*} + \frac{w\ln\frac{\bar{q}S}{w}}{S} - \frac{w\ln\frac{\bar{q}S^*}{w}}{S^*}$, which is further equivalent to $\frac{(\frac{\bar{q}S}{w}-2)\ln\frac{\bar{q}S}{w}-1}{S} > -\frac{\ln\frac{\bar{q}S^*}{w}+1}{S^*} = -\varepsilon$

$\Leftrightarrow (\frac{\bar{q}}{w}\ln\frac{\bar{q}}{w}+\varepsilon)S+(\frac{\bar{q}S}{w}-2)\ln S-2\ln\frac{\bar{q}}{w}-1>0$. Denoting by θ the coefficient of S and with ϕ the constant, the previous inequality can be written: $G(S)=\theta S+(\frac{\bar{q}S}{w}-2)lnS-\phi>0$.

Function $M(S)$ is defined in the text based on equation (1.6) as being equal to $(\delta-F_S+\bar{H}_S)\beta\pi_Q-\beta\pi_S+U_S$. Substituting the given functional forms, it becomes:

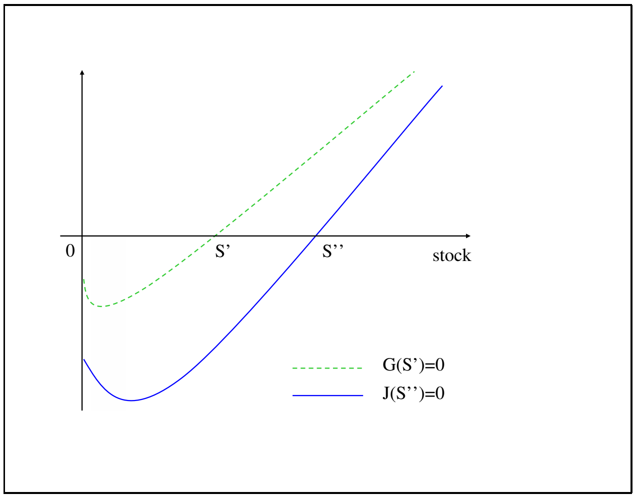
$M(S)=\frac{4pr}{K}S^4+(\delta p-2pr-\frac{5cr}{K})S^3+c(3r-\delta)S^2+\bar{h}(2pw-c\bar{q}-\frac{1}{\beta}\ln\frac{\bar{q}}{w})S-\frac{\bar{h}}{\beta}S\ln S-c\bar{h}w$.

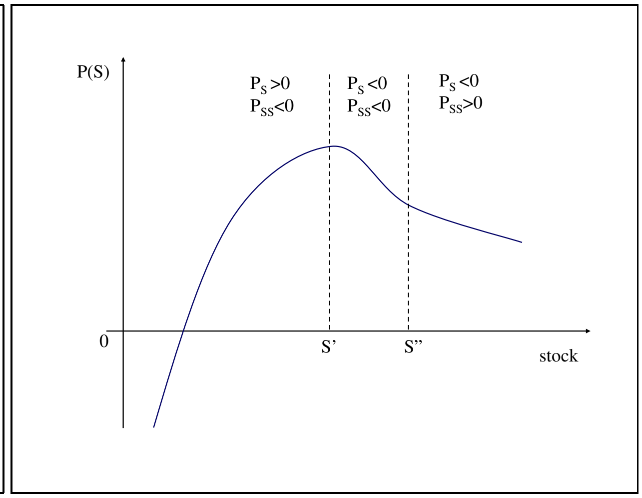
(8). Differentiating (2.7) implicitly with respect to β yields: $(\pi_S+\beta\pi_{SS}S_\beta+U_{SS}S_\beta-\rho_{SS}CS_\beta-\rho_S C_L L_S S_\beta-\rho_S C_L L_S S_\beta-\rho C_L L_{SS}S_\beta)\beta\pi_H-(\beta\pi_S+u_S-\rho_S C-\rho C_L L_S)(\pi_H+\beta\pi_{HS}S_\beta)=-F_{SS}S_\beta\beta^2\pi_H^2$. This implies:

$S_\beta=\frac{\pi_H(u_S-\rho_S C-\rho C_L L_S)}{(\beta\pi_{SS}+U_{SS}-\rho_{SS}C-2\rho_S C_L L_S-\rho C_L L_{SS})\beta\pi_H+F_{SS}\beta^2\pi_H^2-(\beta\pi_S+u_S-\rho_S C-\rho C_L L_S)\beta\pi_{HS}}$ is less than zero if $S>S'$ and $S>S''$, since under the first condition the numerator is positive as $P_S<0$, while under the second, the denominator is negative, as $P_{SS}>0$ (see below).

(9). $P(S)=\rho(S)C(L(S,w))$ and it was shown above that $P_S=\rho_S C+\rho C_L L_S<0$ if and only if $S>S'$. Calculate the condition $P_{SS}=\rho_{SS}C+2\rho_S C_L L_S+\rho C_L L_{SS}>0$ by using the functional forms provided above as follows: $(2\ln\frac{\bar{q}S}{w}-1)(\bar{q}-\frac{w}{S})-\frac{2w}{S}\ln\frac{\bar{q}S}{w}-2w(\frac{1}{S}-\frac{1}{S^*})-2w(\frac{\ln\frac{\bar{q}S}{w}}{S}-\frac{\ln\frac{\bar{q}S^*}{w}}{S^*})>0\Leftrightarrow 2(\frac{\bar{q}S}{w}-3)(\ln\frac{\bar{q}}{w}+\ln S)-1>-aS$, where $a=\frac{2}{S^*}(1+\ln\frac{\bar{q}S^*}{w})-\frac{\bar{q}}{w}$ which further yields $(\frac{2\bar{q}}{w}\ln\frac{\bar{q}}{w}+a)S+2(\frac{\bar{q}S}{w}-3)\ln S-(6\ln\frac{\bar{q}}{w}+1)>0$. Denoting with b the coefficient of S and with c the constant, this becomes: $J(S)=bS+2(\frac{\bar{q}S}{w}-3)\ln S-c>0$. The analysis is now similar to the one in section (7) above, and the graphical solution points to the fact that $P_{SS}>0$ if and only if $S>S''$, which is lower for higher $\bar{q}$ and lower w and S^*.

(10). We need the numerator of the fraction in (2.12) to be positive. The result holds for all profit functions for which the price derivative depends on the level the resource only via quantity, or $\pi_{pS}=Q_S$. Under this reasonable assumption, the result is general. To see this, notice that the numerator in (2.11) is positive if and only if $\frac{\partial\pi}{\partial S}+\frac{U_S}{\beta}-P_S>\frac{\pi_{Sp}}{\pi_{Qp}}\pi_Q$. For $S>S'$ (thus $P_S<0$), a sufficient condition for this last inequality to hold is that $\frac{\pi_{Sp}}{\pi_{Qp}}\pi_Q<\frac{\partial\pi}{\partial S}$. When $\pi_{Sp}=\pi_{pS}=Q_S$ and $\pi_{Qp}=\pi_{pQ}=1$ (e.g. $\pi=[p-c(S)]Q(S)$), this sufficient condition is





equivalent to $Q_S \pi_H < \frac{\partial \pi}{\partial S}$. This is true, since $\frac{\partial \pi}{\partial S} = \pi_S + \pi_Q Q_S$: the partial effect of S on profits is composed of a direct effect that works via lower costs, and another indirect effect that works through a higher steady state harvesting quota. The denominator of the fraction in (2.12) is negative when $S > S''$, thus $P_{SS} > 0$. The graph below plots the probability of conflict as a function of the resource stock, where $S' < S''$ and $\lim_{S \to 0} P(S) = -\infty$, which obtains since $\lim_{S \to 0}[\frac{\gamma}{U^*}(\bar{q} - \frac{w}{S})] = -\infty$ and upon application of the l'Hôpital rule, $\lim_{S \to 0} \Delta U = +\infty$.

(11). If the transfer is conditional on the stock level $(T(S), T_S > 0)$ and if a fraction α of it is embezzled by the corrupt regulator, the problem of maximizing the government's utility has the following Hamiltonian function:

$\mathcal{H} = \pi(p, S, Q) + (\beta - 1)B(Q) + \alpha\beta T(S) + U(S) - P(S) + \mu[F(S) - Q - \bar{H}(S)]$. and the first order conditions:

$\frac{d\mathcal{H}}{dQ} = 0 = \pi_Q + (\beta - 1)B_Q - \mu$

$\frac{d\mathcal{H}}{dS} = \delta\mu - \dot{\mu} = \pi_S + \alpha\beta T_S + U_S - P_S + \mu(F_S - \bar{H}_S)$

$\frac{d\mathcal{H}}{d\mu} = \dot{S} = F(S) - Q - \bar{H}(S)$.

Taking the time derivative in the first condition and substituting into the second yields:

$(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta - 1)B_Q] - \pi_{QQ}\dot{Q} - (\beta - 1)B_{QQ}\dot{Q} = \pi_S + \alpha\beta T_S + U_S - P_S$.

In the steady-state this becomes:

$(\delta - F_S \bar{H}_S)[\pi_Q + (\beta - 1)B_Q] = \pi_S + \alpha\beta T_S + U_S - P_S$.

Similarly, solving the joint government-industry objective maximization (C_2^T) yields:

$(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta - 2)B_Q] = 2\pi_S + \alpha\beta T_S + U_S - P_S$.

Eliminating B_Q between the two equations above yields: $F_S - \bar{H}_S + \frac{\beta\pi_S + U_S - P_S + \alpha\beta T_S}{\beta\pi_Q} = \delta$.

To determine the effect of an increased marginal transfer in the form of an upward shift and/or rotation of the transfer function, express the above condition as:

$E = (F_S - \bar{H}_S - \delta)\beta\pi_Q + \beta\pi_S + U_S - P_S + (\alpha\beta + 1)(\tau + T_S)$. In order to find the effect of T on the equilibrium stock level we added the 'shift parameter' τ. The effect of the transfer on the stock could then be determined as: $\frac{dS}{d\tau}$.[72]

Totally differentiate expression E to get: $\frac{dS}{d\tau} = -\frac{E_\tau}{E_S}$. Since $E_\tau = \alpha\beta > 0$, we get that $sign(\frac{dS}{d\tau}) = -sign(E_S)$, where $E_S = (F_{SS} - \bar{H}_{SS})\beta\pi_Q - (\delta - F_S + \bar{H}_S)\beta\pi_{QS} + \beta\pi_{SS} + U_{SS} + \alpha\beta T_{SS}$. From the concavity of functions F, π, u and T, and when $S > S''$ so that $P_S S > 0$, we get that expression E is decreasing in stock level and consequently $\frac{dS}{d\tau} > 0$: an upward shift in the transfer function increases the conservationist effect of conditional aid. This formally shows the first part of Proposition 4.

We have: $S_\tau = -\frac{\alpha\beta}{(F_{SS} - \bar{H}_{SS})\beta\pi_Q + (F_S - \bar{H}_S - \delta)\beta\pi_{QS} + \beta\pi_{SS} + U_{SS} - P_{SS} + \alpha\beta T_{SS}}$ and we can determine the marginal impacts of the corruption parameters on this conservationist effect. Thus,

$S_{\tau\alpha} = -\frac{\beta[(F_{SS} - \bar{H}_{SS})\beta\pi_Q + (F_S - \bar{H}_S - \delta)\beta\pi_{QS} + \beta\pi_{SS} + U_{SS} - P_{SS} + \alpha\beta T_{SS}] - \alpha\beta^2 T_{SS}}{[(F_{SS} - \bar{H}_{SS})\beta\pi_Q + (F_S - \bar{H}_S - \delta)\beta\pi_{QS} + \beta\pi_{SS} + U_{SS} - P_{SS} + \alpha\beta T_{SS}]^2}$ is positive, since the numerator is positive whenever $\beta[(F_{SS} - \bar{H}_{SS})\beta\pi_Q + (F_S - \bar{H}_S - \delta)\beta\pi_{QS} + \beta\pi_{SS} + U_{SS} - P_{SS}] < 0$ which holds under our assumptions on β and the primitive functions.

Moreover,

$S_{\tau\beta} = -\frac{\alpha[(F_{SS} - \bar{H}_{SS})\beta\pi_Q + (F_S - \bar{H}_S - \delta)\beta\pi_{QS} + \beta\pi_{SS} + U_{SS} - P_{SS} + \alpha\beta T_{SS}]}{[(F_{SS} - \bar{H}_{SS})\beta\pi_Q + (F_S - \bar{H}_S - \delta)\beta\pi_{QS} + \beta\pi_{SS} + U_{SS} - P_{SS} + \alpha\beta T_{SS}]^2} -$

[72] See e.g. Skonhoft and Solstad (1998) p. 30, who use a similar approach to determine comparative statics with respect to a function.

$-\frac{[\alpha\beta[(F_{SS}-\bar{H}_{SS})\pi_Q+(F_S-\bar{H}_S-\delta)\pi_{QS}+\pi_{SS}+\alpha T_{SS}]}{[(F_{SS}-\bar{H}_{SS})\beta\pi_Q+(F_S-\bar{H}_S-\delta)\beta\pi_{QS}+\beta\pi_{SS}+U_{SS}-P_{SS}+\alpha\beta T_{SS}]^2}$ is also positive provided that $\alpha < \frac{(F_{SS}-\bar{H}_{SS})\pi_Q+(F_S-\bar{H}_S-\delta)\pi_{QS}+\pi_{SS}}{F_{SS}\pi_Q+(F_S-\delta)\pi_{QS}+\pi_{SS}+U_{SS}-P_{SS}}$.

If, instead, *the transfer is conditional on the harvest rate* Q, the Hamiltonian for problem (C_1^T)' in the text is:

$\mathcal{H} = \pi(p, S, Q) + (\beta - 1)B(Q) + \alpha\beta T(Q) + U(S) - P(S) + \mu[F(S) - Q - \bar{H}(S).]$ and the first order conditions are:

$\frac{d\mathcal{H}}{dQ} = 0 = \pi_Q + (\beta - 1)B_Q + \alpha\beta T_Q = \mu$

$\frac{d\mathcal{H}}{dS} = \delta\mu - \dot{\mu} = \pi_S + U_S - P_S + \mu(F_S - \bar{H}_S)$

$\frac{d\mathcal{H}}{d\mu} = \dot{S} = F(S) - Q - \overline{H}(S).$

Taking the time derivative in the first condition and substituting into the second yields: $(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta - 1)B_Q + \alpha\beta T_Q] - \pi_{QQ}\dot{Q} - (\beta - 1)B_{QQ}\dot{Q} - \alpha\beta T_{QQ}\dot{Q} = \pi_S + U_S - P_S.$

Program (C_2^T)' yields a similar expression in the form: $(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta - 2)B_Q + \alpha\beta T_Q] - 2\pi_{QQ}\dot{Q} - (\beta - 2)B_{QQ}\dot{Q} - \alpha\beta T_{QQ}\dot{Q} = 2\pi_S + U_S - P_S.$

Imposing the steady-state conditions in both expressions above we get:

$(\delta - F_S + \bar{H}_S)[\pi_Q + (\beta - 1)B_Q + \alpha\beta T_Q] = \pi_S + U_S - P_S$ and $(\delta - F_S + \bar{H}_S)[2\pi_Q + (\beta - 2)B_Q + \alpha\beta T_Q] = 2\pi_S + U_S - P_S$, which upon elimination of B_Q further yields: $F_S - \bar{H}_S + \frac{\beta\pi_S + U_S - P_S}{\beta\pi_Q + \alpha\beta T_Q} = \delta$. This policy rule implicitly gives the steady-state stock of the resource.

To compare this with the resource level in the absence of international aid, notice that the transfer is decreasing in harvesting quota Q or $T_Q < 0$ and then the marginal stock effect is higher with the transfer, ceteris paribus, representing a higher equilibrium stock.

Alternatively, one can think about a simple specific functional form for the transfer: $T(Q) = \theta - \phi Q$ with both coefficients positive, so that $T_Q = -\phi$. Plugging this into the expression for $MSE_{n/c}^T$ above yields a lower marginal stock effect than in the absence of the transfer.

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