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Endogenous Political Economy: On the Inevitability of Inefficiency Under the Natural Resource Curse

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Endogenous Political Economy: On the Inevitability of Inefficiency Under the Natural Resource Curse*

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Abstract

This paper is a first step toward a more fundamental theory of political economy outcomes. We start from the fundamentals of the economy, given by preferences and technology; further, we specify all available technologies for the control of resources – such as armed forces or bribing. We model the interaction of agents in this economy as a game and examine all its equilibria. Equilibrium allocations must be such that individuals maximize their utility and that no group of individuals has the incentive to modify those allocations by (additional) usage of the technologies for the control of resources. The generality of our approach enables us to answer the question "Is there something about the *nature* of a country that makes inefficient equilibria inevitable?" We illustrate our approach by applying it to the natural resource curse. The model predicts that inefficient outcomes – in the form of either conflict or a deterrence army solution – will always occur as long as the value of natural resources to capture is positive and the opportunity cost of time – which partly determines soldiers' wages – is finite.

JEL Codes: H11, O11, P16.

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1 Introduction

Economists have long sought reasons to explain the striking cross-country differences in standards of living. Success in economic development has enormous implication in terms of literacy, longevity, access to adequate health care and many other dimensions that are of first importance for the quality of life. A sustained difference of only a few percentage points in the growth rate of GDP *pc* separates a gruesome and grim existence from the everyday life experience of people in developed economies. The quest to understand the key to economic development was perhaps best summarized in Bob Lucas' much celebrated quote:

> *Is there some action a government of India could take that would lead the Indian government to grow like Indonesia's or Egypt's? If so, what exactly? If not, what is it about the 'nature of India' that makes it so? The consequences for human welfare involved in questions like these are simply staggering: Once one starts to think about them, it is hard to think about anything else.* Robert E. Lucas, Jr. (1988)

Cross-country differences in GDP *pc* growth rates are positively correlated with indicators of aggregate governance. In fact, institutional differences across countries are seen as an important part of the explanation of the heterogeneity of growth experiences. In this paper, we seek an explanation for why inefficient institutions emerge and persist, institutions that prevent a more efficient allocation of resources to prevail. Rephrasing Lucas' quest, we aim to uncover the elements in the "nature" of a country that lead to inefficient resource allocation as is the case for example in the presence of armed conflict, or of a deterrence army that secures control of resources to the benefit of a few, or when bureaucrats manage to extract large rents from other members of society. We believe that these inefficient political economy outcomes or institutions are equilibria of an underlying economic problem that we seek to uncover. We do so by proposing a more fundamental theory of political economy outcomes, as follows.

We start from the fundamentals of the economy, given by preferences and technology; further, we specify all available technologies for the control of resources – such as armed forces or bribing. We model the interaction of agents in this economy as a game and examine all its equilibria. Equilibrium allocations must be such that individuals maximize their utility and that no group of individuals has the incentive to modify those allocations by (additional) usage of the technologies for the control of resources. The generality of our approach enables us to answer the question "Is there something about the *nature* of a country that makes inefficient equilibria inevitable?" We illustrate our approach by applying it to the natural resource curse. The model predicts that inefficient outcomes – in the form of either conflict or a deterrence army solution – will always occur as long as the value of natural resources to capture is positive and the opportunity cost of time – which partly determines soldiers' wages – is finite.[1]

The fact that *all* equilibria of this game are inefficient is what allows us to conclude that inefficiency is inevitable. Even if one dictator were brought down, the analysis shows that because of the "nature" of the economy – manifested in a high stream of exogenous income and a low opportunity cost of time from other activities – a new dictatorship would emerge or else be replaced by the fighting of rival groups for the control of the income associated with natural resources. As long as there is income to appropriate and the opportunity cost of time is low, there is no hope for efficiency in our model economy.

The paper proceeds as follows. In the next section, we lay out in greater detail what we perceive as a new approach to political economy outcomes. In section 3, we apply this approach to an economy rich in natural resources.

2 A More Fundamental Theory of Political Economy Outcomes

The literature on political economy is extremely vast, as documented for example in Allen Drazen's (2000) and Persson and Tabellini's (2000) recent books. In his discussion of these two volumes, Gilles Saint-Paul (2000) argues that the contributions of the past fifteen years in this field have two main features: first, the literature aims at explaining actual economic policies instead of taking them as given; second, it crucially recognizes

[1] We are of course aware that, in reality, some countries have been able to fight off the curse and explore the wealth from natural resource without experiencing armed conflict or the presence of a dictator. In section 3.8, we discuss issues such as financial constraints and different specifications of preferences that would modify our results. Nonetheless, the stark environment presented below – devoid of financial constraints and other frictions – appears as a very natural starting point against which other settings can be compared.

that policies will be the outcome of a political mechanism and, consequently, will reflect the interests of the most powerful groups in society. The literature frequently uses a set of familiar tools, such as the median voter theorem and probabilistic voting, while drawing also on agency theory, overlapping generations' models, game theory and dynamic general equilibrium analysis. The prolific contributions to this literature have spanned an enormous variety of topics, ranging from the determinants of redistributive taxation, school financing, inflation and labor market policies, to mention just a few.

Quoting Saint-Paul, the new political economy "typically generates predictions about how policies that are actually pursued will depend on the distribution of agent's incomes and endowments, and *political institutions*." (my italics) Consider the following example. Start by assuming that the economic problem at hand takes place in a democratic country where individuals have universal voting rights. Postulate a given distribution of wealth in the economy and consider the problem of passing redistributive taxation legislation. Naturally, rich people will oppose high taxes and poor people favor them. If there are very few rich people, the poor will have more than 50% of the vote and will be able to pass their preferred tax rate. If the relative size of the rich group compared to the poor is larger, this result may be overturned. This is a simple but representative example of the typical problems studied in the literature.

The goal of the current analysis is to question the fact that the presence of a democratic environment – or any other set of "assumed" institutions – is exogenous and, in particular, to question its independence from the other fundamentals of the economy, most notably the distribution of wealth. Why should a democracy prevail if there are very rich people who would lose a lot should the poor's preferred tax rate come to pass? What does it mean to have a "democracy" if the rich could bribe public officials not to collect their taxes? Could the poor bribe the same officials back into the "right behavior"? How would the tax men respond if there were many poor people and very few rich people? This same line of questioning applies to other political economy outcomes, as well. Why did dictatorships emerge in certain countries? Was it an unavoidable outcome? Did the distribution of wealth play a role? Do the oppressed have the means to fight the dictator? How many different groups fighting to take hold of an economy's natural resources should we see in equilibrium? What factors – if any – contribute to the emergence of a large number of opposing factions? Is there something about the economic fundamentals of the country that makes inefficient outcomes unavoidable?

We believe that the only way to answer all these questions is to completely bypass "political institutions," such as democracy or the existence of universal voting rights, and instead focus exclusively on economic outcomes as follows. The methodology proposed here starts from the description of the fundamentals of an economy: the number of people in the population as well as their skill type, the wealth distribution, the technology available; and, of crucial importance, the set of technologies available for the effective control of resources. That is, if a group of the population can hire soldiers by paying them wages and providing guns in order to take control of the economy's resources, the costs and properties of the "army" technology should be specified. If it is feasible to bribe public officials and this accomplishes the possibility of avoiding taxes with some probability, the "bribe" technology should be specified as well. Importantly, technologies for resource control are symmetric in that any agent or group of agents has access to them (a different question is, of course, whether or not (s)he has the resources to use them).

To fix ideas, consider the particular problem of the natural resource curse: a country whose soil generates a very large amount of exogenous income, Y. Suppose that, by choosing to work in the country's infrastructure, individuals receive income k from their human capital. They can also form armies by hiring soldiers and providing them with guns. Armies serve the purpose of trying to gain control of natural resources. Military expenditures naturally require financing, and individuals in the economy may choose to organize themselves into coalitions so that they can finance an army, should they not have the resources to do so on their own.

Once the economic fundamentals are fully specified, one can then trace the set of feasible political economy equilibria and answer questions such as: Under what economic conditions will an armed dictatorship emerge? Will there be a countervailing army trying to fight the dictator or is the dictator's army enough to dissuade the creation of a competing army by the oppressed? Will there be multiple armed groups fighting for control of the natural resources? Are there situations where no individual or coalition uses resources to engage armies? Could it be the case that, under these economic fundamentals, *all* equilibria result in inefficient resource allocation? How does any particular equilibrium respond to economic development – i.e. an increment in k, the human capital income that individuals may get if they choose to work? We believe that it is only by considering the entire set of equilibria of this game that we may judge on the inevitability of inefficient outcomes. In other words, while we often observe armed conflicts in countries rich in natural resources, if it were the case that some equilibria resulted in a fully efficient allocation of resources, we would not accept inefficient outcomes as unavoidable. Further, if efficient equilibria existed, they would also be informative about which features of the economic environment may lead to inefficient allocations. Thus, the analysis will provide the tools to understand what elements of the economic fundamentals are driving particular outcomes. It is in this sense that the analysis illustrates the aspects of the "nature" of a country that lead to particular outcomes.

Our intuition is that "democracy" or other political institutions are the solution and window-dressing of an economic problem which we aim to uncover. Perhaps the most important starting point of the analysis is the notion that, contrary to most of the literature (see Acemoglu and Robinson (2005)), the only power that is relevant to accomplish control of resources is economic power; that having the means to engage control technologies is the only source of (*de facto*) power, and that *de jure* power is nothing more than the manifestation of economic power; that "democracies" will prevail only inasmuch as it is either too uninteresting to change the control of resources or that no single group could successfully strive to do so (because others would oppose). And that, in this sense, what deserves examination is the final allocation of resources and how much resources are put by which groups into its control. In fact, the political process is a black box that need not be directly examined: the possibility of side-payments to "correct" the outcome of, say, the voting process is all that is needed to implement the preferred allocation from the point of view of the group with greatest economic power. This is the "theorem" our environment has to offer, extremely dissimilar from the median voter result.

Naturally, other researchers have questioned the exogenous emergence of "institutions" in economic models. We find out contribution closer in spirit to the body of work by H.I. Grossman. As described by Kolmar (2005), Grossman viewed institutions as the equilibrium of a game. That was the case for example in his 1991 piece, where a general equilibrium model of insurrections is presented. There, the technology for insurrection – which included, among others, parameters such as the ability of the rebel leader to succeed – is explicitly considered and the equilibrium allocation of time devoted to insurrection activities, as well as soldiering and production depends on those parameters. However, in this example, the structure of governance is assumed to consist of a leader confronting the rest of the population; no other alternatives are considered, such as the prevalence of simultaneous factions engaged in military conflict. Further, we do not know what – if anything – determines the identity of the leader or whether the assumed political organization of society into a leader and followers is the only equilibrium that could arise given the economy's fundamentals. We believe our approach is more general in the important dimension that it starts one step below and considers instead all the possible institutional configurations that could emerge given the economic fundamentals. It is only through the knowledge of all political economy possibilities that we may ascertain the robustness of given institutions across equilibria.

We believe our approach has uses for other areas of economic theory beyond what is usually labeled as political economy. We find it particularly amenable to the study of frictions limiting free entry in sectors or the free exertion of economic activity. For example, Caselli and Gennaioli (2006) study the implications of different types of reforms meant to restore access to particular sectors of activity, an access limited by inefficient institutions. The analysis proposed here asks the more fundamental questions of why access to sectorial activity was limited, to begin with. Only after understanding why such an outcome emerged in equilibrium are we able to understand the tools necessary to change it. Likewise, in Acemoglu, Ticchi and Vindigni (2006), the persistence of inefficient institutions – in the form of a corrupt body of bureaucrats – is analyzed. A key element in the analysis is the transition to democracy in a future period, a transition which is assumed to take place for sure but whose foundations are unrelated to the economic fundamentals of the economy. It is by understanding the reasons that led to the authoritarian regime in the first place that we may also understand the conditions that might lead to a change in the political economy equilibrium – for example toward "democracy."

We see the methodological approach described above (description of the fundamentals and technologies of control to study the strategic interactions underlying all feasible political economy outcomes) as one contribution of this paper. Our second contribution is to apply this methodology to the natural resources problem, which we pursue below.

3 A Model of the Natural Resource Rich Economy

There is a population of size N. Each period, there is a resource flow of Y. This is exogenous income associated with natural resources. Other income sources are as follows. There is a stock of public capital K which measures infrastructure quality in the country. This infrastructure gives a lower bound on the income that individuals may get. For simplicity, we ignore endogenous labor supply and instead assume that, if an individual decides to work, we will get k units of the consumption good. Income k cannot be taken away from any individual, it is associated with a person's human capital.

There is only one good in the economy, and both the resource flow Y and individual production k are measured in the same units. We expect Y to be large compared to k, so that individuals have a strong incentive to try to get hold of Y. We consider later what happens as k grows large, which we interpret as the process of development.

Utility is identical across individuals and linear in consumption:[2]

$$u(c) = c.$$

Technologies for control of resources are functions $f \in F$. We consider one, only, the building of an army. Armies require people and guns. Consider coalition i. Its army engages S_i soldiers and K_i guns. The output of the army is given by $A_i = f(S_i, K_i)$, where $f(\cdot)$ is Leontieff:

$$A_i = \min\{S_i, K_i\}.$$

A gun uses g units of the consumption good. Because of the Leontieff technology, it follows that, optimally,

$$S_i = K_i = A_i.$$

[2]Linearity was not our preferred functional form for reasons discussed below. We maintain linear utility for analytical tractability.

The probability of securing control of natural resources p is a function of the relative size of the existing armies, as follows. Let n denote the number of armies in the economy, A_i stand for the army size of coalition i, and $\{A_j\}_{j=1}^n$ be the list of army sizes in the economy. Then,

$$p_i \equiv p\left(A_i; \{A_j\}_{j=1}^n\right) = \frac{A_i}{\sum_j A_j},\ p \in [0,1].$$

One important feature of this function is symmetry: armies of identical size have the same probability of getting control of Y. Further, probability p_i is increasing in the size of army i and decreasing in the size of the *sum* of the remaining armed forces. (This already hints at the fact that the optimal choice of army size will depend only on the sum of existing armies and not on their relative sizes.) Probability p_i is also concave in A_i.

A soldier of army A_i who gets wage payment w_i has expected utility of $p_i w_i$. The outcome in case of army defeat is thus normalized to zero.[3]

Timing This is an extensive game with a finite horizon. In the first stage, people choose whether they wish to join a coalition (organization). In stage 2, coalitions form armies by making wage offers to other people in the population who have not joined a coalition. Members of a coalition work and collect income k which they use to pay for guns and salaries. In the third stage, fighting occurs (provided there is more than one army), and payoffs are realized.

Equilibrium Equilibria in our economy will be subgame perfect Nash-equilibria of the dynamic game described above.[4]

3.1 Peaceful Outcome

When no armed forces are engaged, individual consumption equals:

$$c^* = \frac{Y}{N} + k. \tag{1}$$

That is, each individual's consumption would equal the sum of income from human capital plus an equal share of the natural resource income. If the peaceful outcome

[3] Our results would go through as long as the utility outcome under battle loss were less than in the case of military success, w_i, perhaps due to injury in battle.

[4] We will also examine the refinement of coalition-proof Nash-equilibria.

were to prevail, everybody would enjoy consumption level c^* and no resources would be wasted on conflict. As we will see below, peace is not an equilibrium of the game.

3.2 Armed Conflict

We proceed to analyze the equilibria of the game by backward induction.

Stage 3 At the last stage of the game, if more than one army has been hired, there is fighting over Y and payoffs follow. If only one army has been engaged, there is no fighting and the existing army takes control of Y. If no army has been engaged, proceeds of $y \equiv Y/N$ are given to each agent.

Stage 2 At stage 2, individuals who did not get matched with others in coalitions may receive wage offers from coalitions formed in stage 1. They have the option of accepting and working as soldiers, or rejecting. If they reject, they will receive income k from their human capital at stage 3; further, if no coalitions formed in stage 1, they would also receive the additional *per capita* income from natural resources in stage 3. If not made a wage offer, an individual simply works and receives k in the following period, possibly added of y in case the peaceful outcome occurs.

Expected utility of soldiers fighting for coalition i is $p_i w_i$. We assume that there are more individuals unattached to coalitions than wage offers. Thus, there will be a group of people not engaged in fighting and, moreover, would-be soldiers do not have bargaining power over coalitions.

What would be the wage offer that coalitions would have to make soldiers in order for them to accept fighting? If other soldiers accept fighting, this implies that only the coalition getting hold of Y will benefit from natural resources. The opportunity cost of fighting is then income k, with a certainly equivalent of k/p_i. Whether or not offering $w_i = k/p_i$ is enough to induce soldiers to fight depends on what a particular soldier thinks other individuals will do. If any other soldier accepts, then it is better to accept any wage of at least k/p_i, since fighting will prevent all individuals but winning coalition members to have access to natural resource income. If individuals in the population are atomistic, more likely if N is very large, they will ignore the impact of their actions on the possibility of combat. This rules out a situation where *all* individuals receiving wage offers decline those offers, effectively preventing the fighting from taking place: individual recipients of wage offers simply do not perceive their impact on the likelihood of war.

Alternatively, coalitions could offer $w_i = (k + y)/p_i$, effectively compensating soldiers for the loss of natural resource income in addition to the human capital component. This wage offer is equivalent to the no-war alternative and would thus be accepted irrespective of what other wage-offer recipients choose to do. This higher wage rate again rules out an equilibrium where *all* individuals not matched in coalitions would refuse to fight. Under the atomistic assumption, the lower wage k/p_i would suffice to eliminate the peace outcome as well. In what follows, and without loss of generality, we assume that coalitions offer k/p_i to their soldiers and that they accept such an offer. All the result would be qualitatively unchanged if the wage rate equaled instead $(k + y)/p_i$.[5] Therefore, in stage 2, if wage offers are made, they will always be accepted. As we will see below, wage offers are always made in equilibrium, ruling out the possibility of peace as an equilibrium outcome.

Consider now existing coalition i, formed of N_i members who have engaged A_i soldiers and bought A_i guns. Say this coalition pays w_i to its soldiers.[6] Then, the total resource cost to the coalition from engaging an army equals

$$C_i = gA_i + w_iA_i = (g + w_i)A_i. \tag{2}$$

The objective of the coalition is to maximize the expected benefits of its members, net of operational and financial costs. We assume that membership is the least expensive form of financing and so coalitions take on members as the means to finance their military operations. The opportunity cost of funds is normalized to zero, allowing us to disregard financial costs in the coalition's objective function. Say that coalition i has N_i members. Given linear utility, it is optimal to treat all members symmetrically and we thus assume that members' contributions to the coalition are identical. Then, expected profits per coalition member equal

$$\frac{\pi_i}{N_i} = \frac{p_iY - C_i}{N_i}.$$

[5] This can be easily verified by replacing wage k/p_i with $\tilde{k}/p_i$, with $\tilde{k} = k + y$, below.

[6] We assume that the entirety of the wage is paid upfront to soldiers. Results would remain qualitatively unchanged if only a fraction $\delta > 0$ were paid upfront and the remaining $(1 - \delta)w_i$ of the soldier's compensation were paid in case of victory.

Since each member has income of k, a number C_i^*/k of members is necessary to finance C_i^*. Replacing this in the expression for π_i we get:

$$\frac{\pi_i}{N_i} = \frac{p_i Y - C_i}{\frac{C_i}{k}} = k\left(\frac{p_i Y}{C_i} - 1\right). \tag{3}$$

Lemma 1 below shows that maximizing profit per member, as in (3), yields the same result as maximizing the absolute value of the coalition's profits.

Lemma 1 *Let a and b be two functions mapping the positive real numbers onto themselves.*

$$a, b : \mathbb{R}_+ \rightarrow \mathbb{R}_+.$$

Then,

$$\arg\max\,(a - b) = \arg\max \frac{a}{b}.$$

That is, if we maximize the difference $a - b$, we also find the max of the ratio a/b.

Proof. *The proof is graphical. Plot $a - b$ against a/b for values of $a/b \in (0, \infty)$. This ensures that both a and b have the same sign which, given that the functions a and b have positive images, will be positive as well. The difference $a-b$ is a monotonically increasing function of the ratio a/b. Thus, there is a one-to-one relationship between values of the difference and values of the ratio, and this relationship monotonically increasing. Therefore, if we find the argmax of the difference $a - b$, we will also find the argmax of the ratio.* ■

Lemma 1 is useful because it allows us to maximize the absolute value of the coalition's profits (equal to benefits minus costs) instead of maximizing the ration of benefits to costs. Define $a \equiv p_i Y$ and $b \equiv C_i$ and apply Lemma 1.

3.2.1 The Problem of the Coalition

Consider coalition i, facing armed forces $A_{-j} \equiv \sum_{j \neq i} A_j$. Its problem is to:

$$\max_{A_i, w_i} \pi_i = \left(\frac{A_i}{A_i + A_{-j}} Y - C_i\right) \tag{4}$$

s.to:

$$C_i = (g + w_i) A_i \tag{5}$$

$$p_i w_i \geq k. \tag{6}$$

Constraint (6) is the participation constraint of soldiers: it ensures that their expected utility matches at least the outside alternative of working and collecting k. We will assume that there are always strictly more people in the economy than the sum of soldiers engaged by coalitions plus coalition members. This implies that equation (6) is always satisfied with equality as soldiers lack bargaining power to command a higher wage.

Replacing the constraints in the objective function, we get:

$$\frac{A_i}{A_i + A_{-j}} Y - \left(g + \frac{k}{\frac{A_i}{A_i + A_{-j}}} \right) A_i = \frac{A_i}{A_i + A_{-j}} Y - (g + k) A_i - k A_{-j}.$$

The first-order condition with respect to own army size A_i is:

$$\frac{A_{-j}}{(A_i + A_{-j})^2} Y - (g + k) = 0$$

which, solving for A_i, yields:

$$A_i = \sqrt{\frac{Y}{g + k} A_{-j}} - A_{-j}. \tag{7}$$

3.3 Symmetric n-Coalition Equilibrium

In a symmetric equilibrium with n coalitions with equal army size, A, we have $A_i = A$ and $A_{-j} = (n - 1) A$.[7] The probability of success in battle is then:

$$p = \frac{A}{nA} = \frac{1}{n}.$$

Using (7) to solve for A^* we get:

$$A = \frac{n - 1}{n^2} \frac{Y}{g + k}. \tag{8}$$

Therefore, in a symmetric equilibrium, and taking n as given,

$$A^* = A^* \left(\overset{+}{Y}, \overset{-}{g}, \overset{-}{k}, \overset{-}{n} \right),$$

where the derivative with respect to n assumes there will be more than two coalitions (which will always be the case as shown below). Intuitively, the higher the prize Y to

[7] Since each coalition engages one army, we will sometimes use the terms coalition and army interchangeably, in particular when referring to the number of armies.

be attained the greater the coalition size, whereas the greater the gun and wage costs of the coalition, g and k, as well as the reciprocal of the probability of success, n, the lower its optimal size.

Concerning the costs,

$$\begin{aligned} C_i &= (g + w_i) A_i \\ &= (g + kn) A_i. \end{aligned}$$

For a fixed coalition size A_i, total cost is increasing in the relative price of guns and on kn – since this is the wage rate that leaves soldiers indifferent between fighting or not. Since higher k and g reduce optimal coalition size, it is not immediately clear what their total effect on C_i is. Inserting the optimal coalition size found above into the expression for the cost:

$$\begin{aligned} C_i &= (g + kn) \frac{n-1}{n^2} \frac{Y}{g+k} \\ &= \frac{g+kn}{g+k} \frac{n-1}{n^2} Y. \end{aligned}$$

Since n exceeds unity (see below), it follows that higher k and lower g raise C_i, holding n constant. The effect of n is ambiguous. The effect of Y is unambiguously positive since it raises coalition size. Thus,

$$C_i = C_i \left(\overset{+}{k}, \overset{-}{g}, \overset{+}{Y}, n \right).$$

Note that n is being held fixed, for the time being, and n determines the probability of success in a symmetric equilibrium. Therefore, when g increases, optimal coalition size A_i declines (still with constant n), and the total effect on the cost is favorable: C_i declines as well. This is partly the consequence of the Leontieff technology specified for the army operations: the reduction in army size A_i caused by higher gun costs leads to a parallel reduction in the number of soldiers hired and corresponding reduction in the wage bill; the latter effect more than offsets the higher gun cost. Lower C_i will induce entry of more coalitions in equilibrium, as shown below, since, in equilibrium, costs must equal expected return $pY = Y/n$. When k increases, on the other hand, despite the reduction in coalition size for constant n, costs nonetheless increase. Thus, there must be exit of coalitions in equilibrium for the conflict becomes less profitable.

This intuition on the effects of k and g on the equilibrium number of coalitions n^* can be formally demonstrated as follows. Expected profits of the coalition are:

$$E\pi = pY - C = Y\frac{kn(2-n)+g}{n^2(g+k)}.$$

It follows that:

$$\pi = \pi\left(\overset{-}{n}, \overset{+}{g}, \overset{-}{k}, \overset{+}{Y}\right).$$

Since the opportunity cost of capital has been normalized to zero, coalition members will accept to finance the coalition as long as expected profits are positive. Free entry of coalitions will drive expected profits to zero. Solving for the equilibrium n, we get:

$$E\pi = 0 \implies n = 1 \pm \sqrt{1+\frac{g}{k}}.$$

The positive root must be selected for n to take on a positive value. Finally, the equilibrium value of n is

$$n^* = 1 + \sqrt{1+\frac{g}{k}}. \tag{9}$$

We have that, as anticipated, n^* depends positively on g and negatively on k. Interestingly, n^* exceeds unity. Further, a higher price of guns leads to an *increase* in the equilibrium number of coalitions, but, if we consider the expression for A^* in (8), we see that the size of each coalition is getting smaller and smaller (both the direct effect of g on A^* and the indirect effect through n^* lead to a smaller army size).

The effect of higher k on A^* appears ambiguous. Holding n fixed, it reduces coalition size, but it also reduces n, which raises coalition size. Substituting (9) in (8), we get:

$$A^* = \frac{1}{\left(1+\sqrt{\frac{1}{k}(g+k)}\right)^2}\frac{Y}{\sqrt{k(g+k)}}.$$

Some algebra shows that the following inequality is a sufficient condition for the denominator to be an increasing function of k:

$$2k > g. \tag{10}$$

Finally, we get:

$$A^* = A^*\left(\overset{+}{Y}, \overset{-}{g}, \overset{-}{k}\right),$$

where the negative sign on k is conditional on (10) holding.

An implication of our results for n^* and A^* under symmetric equilibria is that the number of coalitions forming is always strictly positive, as is the amount they spend on wasteful activities. Finally, we define $\tilde{A}$ as the total armed forces under a symmetric equilibrium, $\tilde{A} \equiv nA_i$. From the zero profit condition, it follows that

$$nC_i = Y \iff n\left(g+kn\right)A_i = Y \iff A_i = \frac{Y}{n\left(g+kn\right)}.$$

Thus, total armed forces $\tilde{A}$ are given by:

$$\tilde{A} = \frac{Y}{g+kn}.$$

We now consider what happens as $k \to \infty$, which we interpret as the process of development.

$$\lim_{k\to\infty} n^* = \lim_{k\to\infty} 1 + \sqrt{1+\frac{g}{k}} = 2.$$

$$\lim_{k\to\infty} A_i = \lim_{k\to\infty} \frac{n-1}{n^2}\frac{Y}{g+k} = \frac{1}{4}\lim_{k\to\infty}\frac{Y}{g+k} = 0.$$

$$\lim_{k\to\infty} \tilde{A} = \lim_{k\to\infty} nA_n = 0.$$

We have two rather remarkable results as $k \to \infty$. First, the number of coalitions converges to 2, and many developed countries are polarized around two large political parties. Second, army size goes to zero: as k increases, the number of coalitions drops to 2 and they spend less and less. As a consequence, the total armed forces in the economy also vanish. Thus, as the process of development ensues, spending on wasteful control activities goes to zero.

Regarding the effects of g,

$$\lim_{g\to\infty} n^* = \infty$$

$$\lim_{g\to\infty} A_i = 0.$$

$$\lim_{g\to\infty} \tilde{A} = \lim_{g\to\infty} nA_i = \lim_{g\to\infty} n\left(\frac{n-1}{n^2}\frac{Y}{g+k}\right) = \lim_{g\to\infty}\frac{Y}{g+k} = 0.$$

As the relative price of guns increases, more coalitions form but their size becomes arbitrarily small, and the latter effect dominates on the size of total armed forces, which also goes to zero.

Stage 1 The financing of each coalition is made by the engagement of $N_c^* \equiv A^* \left(g + \frac{k}{p^*}\right)/k$ members. Thus, $n^* N_c^*$ individuals choose to join coalitions of size N_c^* in the first stage. The remaining $N - n^* N_c^*$ individuals in the population choose not to become coalition members. In the second stage, a total of $n^* A^*$ wage offers are made and accepted. The remaining $N - n^* (N_c^* + A^*)$ individuals simply work and receive k. The strategy of each individual is optimal given what others are doing at each stage and the backward induction method used to solve for the equilibrium ensures subgame perfection. We note that, although we can characterize equilibria in terms of optimal coalition and army sizes, as well as the number of coalitions, the model is silent concerning the allocation of particular individuals to specific groups. That is, we have multiple equilibria in the sense that one particular person might be a coalition member in one equilibrium and a soldier in another. But up to the identity of the players, the symmetric equilibrium is unique. (We will come back to the identity issue in section 3.8.)

This summarizes the characterization of symmetric subgame-perfect Nash-equilibria of our game.

3.4 Deterrence

In this section, we examine whether or not there is a deterrence equilibrium in our economy. In such an equilibrium, one coalition would engage an army just large enough so that other coalitions would have no incentive to form. To understand how to find the deterrence army size, we must consider the objective function of coalition i, to

$$\max_{A_i} \left\{ \frac{A_i}{A_i + A_{-j}} Y - (g + k) A_i - k A_{-j} \right\}.$$

Graphically, profits are the difference between two schedules. The first, $p_i Y$, measures expected revenues, has origin at $A_i = 0$, is strictly increasing and strictly concave. The second, the straight line $(g + k) A_i + k A_{-j}$, has an intercept at $k A_{-j}$ and a constant slope of $(g + k)$. Optimality requires A_i^* to be such that the slope of $p_i Y$ equal $g + k$. Although necessary, this is not a sufficient condition for coalitions to form. In fact, if the cost schedule is everywhere above the benefits – more likely if A_{-j} is very large – coalition i will have negative expected profits and should not operate. Coalition i will behave optimally *and* have zero profits provided the cost schedule is tangent to the benefit function and A_i is given by that single intersection point. If there is a level of A_{-j} that accomplishes this, that level will be enough to keep coalition i out: since the best it could do would be to form to have zero profits, it might as well stay out. More generally, this also shows that, if A_{-j} is low enough for additional coalitions to enter, these entrants will need to attain a certain minimum scale in order to be profitable, given by the (lowest) intersection of the pY schedule and the cost line $(g+k)A_i + kA_{-j}$.

For clarity, let us consider also what would happen if A_{-j} exceeded the level previously defined, that exactly leaves any entering coalition with zero profits. Higher A_{-j} raises the intercept of the cost schedule and moves it parallelly upward. Further, higher A_{-j} reduces p_i and thus causes the benefit schedule to move downward, still with intercept at the origin. Thus, the benefit and cost schedules would not longer be tangent, the cost schedule would be everywhere above the benefit schedule and coalition i would have negative profits if it chose to enter. Therefore, selecting A_{-j} so that coalition i's cost and benefit schedules are tangent is the best that a dictator wanting to implement deterrence can do.

Let A_{det} be the smallest army size that will implement deterrence. Then, it must be the case that the resulting A_i^* is given by the first-order condition of coalition i and, at the same, time, its profits are zero. This is true when

$$A_i = \sqrt{\frac{Y}{g+k}A_{\text{det}}} - A_{\text{det}}$$

and

$$\frac{A_i}{A_i + A_{\text{det}}}Y - (g+k)A_i - kA_{\text{det}} = 0$$

both hold. Solving for A_{det} we get:

$$A_{\text{det}} = \frac{gY + 2kY \pm 2\sqrt{Y^2k^2\left(1+\frac{g}{k}\right)}}{g^2}.$$

It can be shown that the higher root is such that the implied A_i^* is negative. The solution is thus:

$$A_{\text{det}} = \frac{gY + 2kY - 2\sqrt{Y^2k^2\left(1+\frac{g}{k}\right)}}{g^2}. \qquad (11)$$

We may compute A_{det} alternatively as follows. Recall that the condition for deterrence is that a potential entrant, once setting A_i to its optimal size, has expected utility of exactly zero. For this reason, the coalition does not form. Note also that, in the first-order condition for army size, the armed forces of other coalitions show as a sum and the individual parcels do not have any effect beyond that sum. Thus, the deterrence army size will equal the total armed forces of $(n-1)$ coalitions in the symmetric equilibrium. At this level, the n^{th} coalition is indifferent between forming or not because its profits would be zero in both cases. The fact that the deterrence coalition is able to stave off a competing army whose size would have equaled that of a single coalition in the symmetric equilibrium is of course beneficial for those sponsoring the deterrence army: the deterrence coalition has strictly positive profits. Therefore:

$$A_{\text{det}} = \frac{n-1}{n}\tilde{A} = \frac{n-1}{n}\frac{Y}{g+nk} = \frac{\sqrt{1+\frac{g}{k}}}{1+\sqrt{1+\frac{g}{k}}}\frac{Y}{g+\left(1+\sqrt{1+\frac{g}{k}}\right)k}.$$

We have then:

$$A_{\text{det}} < \tilde{A}.$$

Regarding the effect of development and the price of guns on deterrence, we have:

$$\lim_{k\to\infty} A_{\text{det}} = 0$$

$$\lim_{g\to\infty} A_{\text{det}} = \lim_{g\to\infty} \frac{1}{\frac{1}{\sqrt{1+\frac{g}{k}}}+1}\frac{Y}{g+\left(1+\sqrt{1+\frac{g}{k}}\right)k} = 0.$$

Thus, the property that development (growing k) eliminates inefficient use of resources is common across equilibria of the game, be it under the conflict of multiple armies or under the deterrence solution. A higher gun price also leads to a reduction in the army size of the deterrence army.

In the deterrence equilibrium, a total of $N^*_{\text{det}} \equiv A_{\text{det}}(g+k)/k$ individuals choose to join a coalition of N^*_{det} size. The remaining individuals choose not to join a coalition. In the second stage, A_{det} wage offers of k are made and accepted. The remaining $N - N^*_{\text{det}} - A_{\text{det}}$ individuals do not fight and simply work to get k. All individuals are acting optimally given what others are doing and backward induction ensures subgame perfection. Thus, deterrence is another subgame-perfect Nash-equilibrium of our game. As in the symmetric-equilibrium case, the deterrence equilibrium is unique up to the identity of the players.

3.5 Asymmetric Coalition Size

Could coalitions of different sizes coexist? If this were to happen, larger coalitions would have higher equilibrium profits than smaller ones. We show that, in the current environment without frictions, it is not possible to have coalitions of different sizes. Therefore, equilibria in our model will be of two types: symmetric n-coalition equilibrium or of the deterrence type.

Proposition 2 *There are no coalitions of different size in equilibrium.*

Proof. Suppose, for contradiction, that there are coalitions of different sizes. Let two of the coalitions in this equilibrium have sizes A_i and A_j, let $\tilde{A}$ indicate the total number of armed forces in the equilibrium (the sum across all coalitions), and, without loss of generality, let coalition i be larger than coalition j. If both A_i and A_j have the optimal size given $\tilde{A}$, then both A_i and A_j have to satisfy the first-order condition (7). Define $\theta_i \equiv A_i/\tilde{A}$ and θ_j similarly, with $\theta_i > \theta_j$. We may now rewrite (7) as:

$$
\begin{aligned}
A_i &= \theta_i \tilde{A} = \sqrt{\frac{Y(1-\theta_i)\tilde{A}}{g+k}} - (1-\theta_i)\tilde{A} \iff \\
\tilde{A} &= \sqrt{\frac{Y(1-\theta_i)\tilde{A}}{g+k}} \implies \tilde{A} = \frac{Y(1-\theta_i)}{g+k}.
\end{aligned}
$$

Similarly, for A_j,

$$
\begin{aligned}
A_j &= \theta_j \tilde{A} = \sqrt{\frac{Y(1-\theta_j)\tilde{A}}{g+k}} - (1-\theta_j)\tilde{A} \implies \\
\tilde{A} &= \frac{Y(1-\theta_j)}{g+k}.
\end{aligned}
$$

From the assumption that coalition i is greater than j, it follows that

$$
\frac{Y(1-\theta_j)}{g+k} > \frac{Y(1-\theta_i)}{g+k},
$$

and so we get two different solutions for $\tilde{A}$, a contradiction. ■

3.6 Equilibrium Concept and Refinements

The game played by agents in our economy has two subgame perfect Nash-equilibria.[8] Given that, in our environment, we examine the endogenous formation of groups, it seems

[8] We ignore here the multiplicity of equilibria coming from changes in the identity of players.

natural to raise the standard of the equilibrium concept by asking if the actions we have assigned to these groups are optimal to all the group's members or if, instead, they could do better by choosing to reorganize themselves into smaller or larger groups. We next examine whether the Nash-equilibria we found are also coalition-proof equilibria, *a la* Bernheim and Peleg (1987).

Coalition-proof equilibria is a refinement of Nash-equilibria applying to situations where players can communicate before the game and coordinate their strategies. It refines the Nash concept by imposing that, through the combined choice of action, a group of agents will not have an incentive to deviate from the equilibrium play, taking as given the actions of the remaining players. Further, if deviant groups exist, the candidate deviation must be coalition-proof so that none of the deviant members of the original group wish to further deviate from the original deviation.[9]

We begin by applying the coalition-proof concept to the coalitions in our model. We have found optimal coalition size taking as given the armed forces of other coalitions. Clearly, in the symmetric equilibrium case, it would not be optimal for coalition members to break from their original coalition and form new ones. The reason is that they would start out with a larger number of opponents A_{-i}, and thus have access to lower profit opportunities than when acting within their original group. (Higher A_{-i} lowers the expected revenue schedule $p_i Y$ and raises the cost schedule $kA_{-i} + (g+k)\,A_i$.) Further, we have shown earlier that absolute profit optimization also yields the highest value of profit per coalition member, and so that there is no benefit from deviating and having a smaller size. Thus, the symmetric equilibrium is robust to a downsizing of the original coalition group size.

There is, however, a way to improve the utility of at least some of the $n^* N_c^*$ agents engaged in sponsoring coalitions. They could agree to join forces into a single-coalition and pursue the deterrence strategy. Thus, a subset of size N_{det}^* – strictly smaller than $n^* N_c^*$ – of the $n^* N_c^*$ individuals who were sponsoring the n^* coalitions would get together and instead form a single coalition which would follow the continuation strategy of the

[9] Deviations by a group of agents from the equilibrium strategy are checked against further deviations but only by members of the original deviant group. That is, agents who deviated jointly in a first stage cannot proceed to additional deviations with players who were following the strategy prescribed by equilibrium.

deterrence coalition (make A_{det} wage offers, and so on). The remaining $n^*N_c^* - N_{\text{det}}^*$ would not contribute to the coalition anymore and have expected income of k, just as they did when sponsoring the coalition (since free entry of coalitions brought profits to zero). The latter group would be indifferent between this deviation and the symmetric equilibrium outcome, whereas those individuals sponsoring the deterrence army would be strictly better off. Would there be additional deviations? It can be shown that there is no gain from further reductions in coalition size. If a subgroup of the N_{det}^* decided to split from the original coalition, it can be shown that, irrespective of the size of the remaining group, its expected profits would decline. Further, no other group of players could gain by deviating and coordinating their strategy. This establishes the deterrence solution as coalition-proof.[10] This discussion informally establishes the following result:

Proposition 3 *The deterrence equilibrium is the unique coalition proof, subgame perfect Nash-equilibrium in our economy.*

Should we focus attention on the deterrence outcome alone and ignore the symmetric case? The identity of coalition members in reality is likely to be determined by things outside the model. (See, in particular, the discussion on financial constraints below.) Discarding the symmetric equilibria would be tantamount to considering only the monopoly outcome – as opposed to a cartel equilibrium – when analyzing the competitive structure of a given market, for example. While we find coalition-proof an insightful refinement of Nash-equilibria, we also see the Nash concept as potentially very illuminating for the strategic aspects of our game.

3.7 The Cost of Conflict

What is the resource cost of conflict? From the zero-profit/free-entry condition for coalitions, it follows that:

$$\begin{aligned} pY - C_i &= 0 \iff \\ \frac{Y}{n} &= C_i \iff nC_i = Y. \end{aligned}$$

[10] Both Nash-equilibria found are coalition-proof with regard to other possible 'group' deviations in the economy, where the groups are general and entail any combination of individuals.

Thus, the total resource cost of conflict equals Y under the symmetric equilibrium case, the income to be appropriated at the outset.

As discussed earlier, the deterrence army is smaller than the total armed forces of the symmetric equilibrium. In addition, this coalition has the lowest wage bill per soldier, since its soldiers will gain control of resources with probability 1. So, the deterrence solution is more efficient than the symmetric equilibrium case. The deterrence solution's cost equals $A_{\text{det}}\,(g+k)$.

3.8 Discussion

The analysis shows that there will always be inefficient military activities going on – either in the form of multiple coalitions fighting each other or in the deterrence form – provided k is finite and Y is positive. Since both symmetric equilibria and deterrence are equilibria of the model, it does not give us *a priori* ways of knowing which one will prevail.

The model predicts that, in equilibria with more than one coalition, coalition size should be identical. Should this not be the case, frictions outside the model must be operating. One likely candidate is financial frictions and/or coordination costs. In fact, we could have framed the coalition's problem as that of a firm maximizing its expected profits and issuing shares to get the resources for financing its operations. The shareholders in our economy are the coalition members who bring in their income to finance the coalition's army. The model assumes that the capital structure of the coalition does not affect its operations and thus, that as many shares as required to attain optimal army size will be issued.

Of course financial constraints are likely to be an important consideration for these coalitions. Even if it were feasible to gather as many coalition members as needed to pay for C_i^*, the coordination costs of this endeavour would likely get out of hand: issues of trust, of credible repayment and internal coordination would likely loom large even under small coalition sizes. This suggest that, from an operational point of view, it is less costly to have the smallest possible coalition. It follows that the wealthy have a comparative advantage at setting up the coalition since they are more likely to be able to operate with fewer additional financiers and to have fewer coordination problems.

In fact, coalitions may not even be able to form if they would require too large a number of financiers just to attain a profitable size (recall that, for small A_i and large A_{-j}, coalition i is making negative profits). In our environment, therefore, a link between wealth inequality and the persistence of inequality emerges from the difficulty in contesting the domain of an established deterrence force or in joining the conflict between established big groups, for example, a difficulty which is rooted on the lack of adequate financial means. On the contrary, if the country has a middle class with some means, the model predicts that fighting between virtually identical coalition sizes will likely take place, or, instead, we simply witness the deterrence solution. Of course we have ignored the possibility of external financing. After all, if getting hold of Y is attractive to locals, it will also be attractive to rich foreigners with means. If foreign financing is available to all parties, the model predicts that conflicts among multiple parties should be even.

Is there a way of avoiding the inefficient use of resources – either through conflict or through deterrence? In other words, is there a way of approaching the efficient solution? The reason for the conflict is the existence of Y and the fact that k is small. One issue we seek to examine in future research is the dynamic relationship of k with conflict. It is likely, however, that one consequence of conflict would be the worsening of the country's infrastructure and thus a reduction in future k. Lower k, in turn, lowers the cost of conflict, raises army size across equilibria and the number of coalitions fighting in the symmetric case. From this point of view, conflict today makes conflict more likely tomorrow.

One solution would be for the countries that buy the natural resources to earmark the income from its sales for development purposes, for example, or to require that goods be certified not to have originated from a conflict area, the latter option resembling the Kimberley accords for diamonds. But the new question that arises here is of course whether this international agreement is individually rational from the point of view of outsiders, be they rich individuals who could finance the control of Y and reap its benefits, or be they rich governments of neighboring countries. If outside countries are rich enough (in the sense of enjoying a very large k themselves and thus of having no interest in getting hold of Y), they may be willing to enforce this agreement. Informally, enforcement of this agreement would seem to depend on the existence of a sufficiently large group of rich countries that could credibly commit not only not to finance the capture of Y for their own exclusive use but also to putting in place mechanisms (international courts with adequately high punishments) that would be persuasive enough to other tempted countries and/or individuals.

Tractability imposed that linear utility be used in the model. However, linear utility takes away important dimensions of decision making that would alter the results as follows. Considering decreasing marginal utility would have the important consequence that getting hold of income Y is no longer as appealing as in the linear case. Put differently, if individuals enjoy a large k, then additional consumption is less appealing. Further, if others in society (soldiers) also enjoy a high k, it is expensive to pay them enough to fight for you. Therefore, in the case of concave utility, a little development might go a long way in avoiding conflict both because the benefits are no longer so highly appreciated and the costs become higher.

Moving further away from linear utility, conflict might fail to emerge under two alternative formulations of preferences. First, if preferences display some kind of satiation threshold, above which marginal utility is zero, this will make coalition formation uninteresting in a rich country, where k is very large. This might help explain why conflict did not break up in Norway following the discovery of oil, whereas a very poor country such as Nigeria has been plagued by conflict. Second, in the case of minimal subsistence requirements (Stone-Geary preferences, for example), people might be too poor to finance an army and thus lack the means to fight. In this scenario, however, it would have to be the case that no single individual had the means to finance a coalition nor access to foreign funds.

4 Conclusion

This paper proposed a new approach to political economy outcomes. It starts at a more general level than the existing work by examining the fundamentals of the economy. Given those, it then considers all equilibria that may arise in the noncooperative game of trying to get hold of society's resources. The approach was applied to the natural resource curse.

We believe the generality of our method is a key tool in the full understanding of political economy outcomes and what enables us to identify the elements in the nature of a country that render inefficient outcomes unavoidable.

We seek to extend our analysis of the natural resource curse to incorporate dynamics. We also aim to explore the enormous variety of constellations of inefficient institution outcomes from the vantage point of the method proposed here in the hope of finding their determinants and potential solutions.

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