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ABSTRACT

We discuss the relationship between a resource-rich developing country and a multi-national corporation (MNC) that is developing its resources for the international market. We model the connections between transparency, permeability (defined as the amount of resource rent that leaves the country) and economic development, considering the cases of democracy and autocracy. We begin by considering the role of permeability in domestic politics, showing that a decrease in permeability will always benefit the incumbent, whether the country is a democracy or an autocracy. We then suggest that the relation between the host and the MNC has the features of a classical and quite intractable version of the hold-up problem, and that this may provide the MNC with incentives to influence political outcomes within the host country by whatever means are at its disposal. The hold-up problem can be overcome by the use of a Bilateral Investment Treaty that restricts the host country's ability to alter the terms of any agreement into which it has entered, and we investigate why a country might enter into a treaty that limits its freedom of action in this way. A possible answer is to be found in the capacity of a small number of poor countries to "tip" an equilibrium where none sign such treaties to one where all sign, in the process making all worse off. Our analysis provides a micro foundation for the "obsolescing bargain model" of host-MNC relations.

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1 Introduction

Our aim is to explore issues relating to the political economy of many income-poor but resource-rich countries. This is hardly a new topic: there is an extensive literature on both the political and economic aspects of this, focussing on the resource curse, and noting that in many resource-rich countries, the population are poor in spite of the country's wealth: wealth beneath the surface has not been transformed into purchasing power in the hands of the citizenry. Additionally, and perhaps related to this, resource-riches are often associated with bad governance. Nigeria is a wealthy country whose population is mostly poor, and which is politically unstable and badly governed: Saudi Arabia and other Gulf countries are more prosperous but autocratically ruled. There are, however, resource-rich countries that are prosperous, stable and democratic. Botswana is both prosperous and democratic (as are a number of developed resource-rich countries such as the US, Canada and Australia). Such dramatic differences in outcomes have naturally attracted the attention of researchers (see Ross (2013) for a review). Sachs and Warner (1999) were amongst the first to point out that resource-rich countries appeared to grow less, rather than more, than similar resource-poor countries, and Karl (1997) noted that the massive resource transfer in favor of oil-producers associated with the oil shocks of the 1970s seemed to lead rather counter-intuitively to economic deterioration and political decay. A series of papers on the resource curse can be found in Humphries et al. (2007), and Dunning (2008) contains an interesting analysis of the political aspects of being resource rich, suggesting how oil dependence can lead either to democracy or to autocracy, depending on the details of the domestic political configuration. Ross (2012) makes the case that oil resources predispose to corruption.

The particular dimension of concern here is rather narrower and is the nature of the deal struck between a resource-rich country and the multinational corporation (MNC) which develops its resources, and the way in which this deal interacts with domestic politics. We focus on what we call the "permeability" of this deal, which here we quantify as the fraction of the total resource rent that leaves the country; on the transparency of resource-related transactions; and on the level of economic development. Chichilnisky-Heal (2014)[1] presents a broader interpretation of the idea of permeability, inter-

[1] http://politicalscience.yale.edu/sites/default/files/ncheal_-_003.pdf

preting it as a measure of the degree to which the democratic government and its processes have been "permeated" by actors other than its domestic constituent base. As we shall see in section 3, there are compelling reasons why a resource-producing corporation might wish to intervene in the domestic politics of the host country, making the host "permeable" in this broader sense. We are interested in how these factors interacts with other issues and in particular with domestic political processes. International financial institutions such as the IMF and the World Bank are often parties to these interactions, suggesting or even emphasizing certain preferred approaches and exerting influence over the choices made by the host country government. We simplify here by focusing only on the interactions between the host country and the MNC, but studies of the interactions between host governments and international financial institutions in the cases of Mongolia and Zambia are reported in Chichilnisky-Heal (2014).

We explore these issues in the context of a simplified version of the model used by Dunning (2005) and Dunning (2008), which is in turn an adaptation of the Acemoglu-Robinson model of political transitions to resource-dependent countries (Acemoglu and Robinson (2001)). (We call this the ARD model.) The main simplification is that we work with a static version of the model, which can be thought of as representing the stationary equilibria of the system. There are two classes, the elite and the masses, who are vying for control of the society. Whichever is in control is threatened by the possibility that the other will mount a successful challenge and take over the government. There is an exogenous source of non-resource income, plus income from the exploitation of natural resources. Non-resource income accrues to both groups, whereas only the elite benefit from resource rent. Income of both types accruing to the elite is taxed to provide public goods, which benefit only the masses.

Whichever group is not in control can mount a challenge to the ruling group, with a certain probability of success, and with known payoffs to successful and unsuccessful outcomes. The ruling group can ward off this threat by ensuring that the out-group reach a welfare level at least equal to the expected outcome of an attempted overthrow - we call this a "consent constraint." This captures one of the main ideas of the ARD model.

Resource rent is divided two ways, between the elite and the MNC developing the resource. The fraction P accruing to the MNC, and so leaving the country, is called permeability. Not all of the resource rent is visible to the masses, only a fraction t where t stands for transparency. The fraction

invisible to the masses can not be taxed to fund the public good. So both groups have an interest in reducing permeability, though in this they are opposed to the MNC, but the two domestic groups have opposed interests with respect to transparency.

The host country is dependent on the MNC for the development of the resource, but this dependence depends on and falls with the level of the hosts' development. The MNC's incentive to develop the resource, and so generate rent for use in the host country, depends on the permeability: the more money it can extract, the greater its incentive to develop the resource base and the greater the total rent - but also the greater the fraction flowing out of the country.

Within this context we study the interactions between transparency, permeability and development, and how these affect the domestic political equilibrium. We show that whichever party is in control has a strong incentive to reduce permeability, as the host country's transparent (visible to the ruling group) benefits from doing so accrue exclusively and directly to the ruling group, and only the ruling group benefits from a reduction in permeability. This could go some way toward explaining the focus of domestic politics on resource-related issues in resource-dependent developing countries. If the masses are in control they gain from an increase in transparency, and vice versa, so that we expect democracies to be more transparent than autocracies.

We then investigate the nature of the deal struck between the host country and the MNC. The relationship here is complex, as it contains both cooperative and non-cooperative dimensions. Up to a certain level of permeability, both host country and MNC stand to gain from an increase in permeability, as it gives the MNC greater incentives to invest in developing the resource base, benefiting both parties, and the gain from a greater resource base more than outweighs the loss to the host country from greater permeability. However beyond this critical point interests diverge: the MNC gains from more permeability while the host country loses. The critical level of permeability decreases as the level of economic and political development increases, as more developed host countries are less in need of the skills and resources offered by MNCs. So the potential for conflict between the host and the MNC increases with development, and it is reasonable to assume that both parties anticipate this when negotiating contractual relationships. We show that the relationship between the host and the MNC has the classic features of a hold-up problem Tirole (1986). Many features of the deals seen in practice, such

as stability agreements or some of the features of bilateral investment treaties (BITs), can be explained by this anticipation of increasing conflicts, as can some features of the roles played by international financial institutions. We show that although widely adopted by developing countries, BITs may make them worse off, in an argument which extends those of Guzman (1997) and Bubb and Rose-Ackerman (2007).

In section 2 we set out the basic model developing the relationship between transparency, permeability and domestic political equilibrium. In particular we look at the comparative statics of the equilibrium with respect to changes in permeability, showing that the benefits of a reduction in permeability, or the costs of an increase, accrue exclusively or largely to the ruling group. A decrease in permeability is a very attractive strategy for a ruling group seeking to increase its income. When the masses are in control, the elite can share in the gains from a reduction in permeability if transparency is less than complete, because a lack of transparency shields some of the gains that accrue to them from taxation by the ruling masses.

In section 3 we investigate the nature of the bargaining process between the host country and the MNC: it is this process which actually determines the permeability. We investigate the conflict between the host and the MNC. An agreement that the host reaches with the MNC today will generally seem to the host to involve an unacceptably high level of permeability in the future. This built-in and growing conflict leads to a hold-up problem and explains many of the features found in host-MNC agreements, so-called "stability agreements," which make it extremely difficult to revise the agreement. Section 3 offers some conclusions, and two appendices present mathematical details of some of the arguments.

2 A formal model

The total population is taken to be distributed uniformly on the unit interval $[0, 1]$. A fraction r of the population is rich and constitutes the political and economic elite. The remainder are the masses. There are two sources of income in this society: income from producing goods and services, which totals I, and rent from the production of extractive resources, totaling R. Resource rent is defined as the difference between market price p and marginal extraction cost, so that assuming a given market price the total of resource

rent is

$$R = \int_0^Q (p - mec\,[q])\,dq$$

where Q is the output of the resource and $mec\,[q]$ is the marginal extraction cost of the $q-th$ unit extracted.

A fraction $f > r$ of the income from goods and services accrues to the elite. Some of the resource rent accrues to foreign entities, namely the MNC. This fraction is denoted P for "permeability." The remainder of the resource rent goes entirely to the elite, whose total income per capita before taxes is therefore

$$I_e = I\frac{f}{r} + R\frac{(1-P)}{r} \tag{2.1}$$

Only a fraction t (for transparency) of this resource rent is visible to the masses: the remainder is hidden. All of the income from production is visible, and visible income is taxed at a rate τ, with the proceeds of the tax used to finance the provision of public goods, the benefits of which accrue entirely to the masses. The after-tax income of the elite I_e^a is

$$I_e^a = (1-\tau)\,I\frac{f}{r} + (1-\tau)\,t\frac{R}{r}\,(1-P) + (1-t)\,\frac{R}{r}\,(1-P) \tag{2.2}$$

The income per capita of the masses is correspondingly

$$I_m = I\frac{(1-f)}{1-r} + g \tag{2.3}$$

where

$$g = \tau I f + \tau t R\,(1-P) \tag{2.4}$$

The public good is not divided by population as being a public good it is fully available to all. Each group's preferences are represented by a smooth strictly concave utility function of per capita income, denoted U_e and U_m respectively.

2.1 Democracy

To understand the role of changes in permeability on the equilibrium we consider two governance cases. In the first we have a democracy, the median voter is a member of the masses, and the masses control the country to maximize their utilities. However in doing this they face a constraint: the

elite may be able to overthrow the democracy and take command, and will attempt to do so if their wellbeing falls below a certain critical level. So the masses must maximize their wellbeing subject to the constraint that the welfare of the elite is high enough to prevent them from trying to overthrown the democracy. We denote the welfare level needed to prevent the elite from attempting a coup by U_e^c.

We can think of U_e^c as being calculated as follows. If the elite carries out a coup successfully then their wellbeing is U_e^*. The probability of a coup being successful is s_e. The welfare level after an unsuccessful coup is U_e^l. So if the elite attempts a coup, then their expected welfare level is

$$U_e^c = s_e U_e^* + (1 - s_e)\, U_e^l \tag{2.5}$$

and this determines the welfare level that the masses have to allow the elite to attain to prevent a coup.

We assume that the constraint $U_e \geq U_e^c$ will bind so that

$$U_e = U_e^c \tag{2.6}$$

This is equivalent to a participation constraint in a principle-agent problem: the elite must be given a sufficiently attractive outcome that they willingly participate in the economy rather than trying to overthrow the system. We call this the "consent constraint" - hence the c in U_e^c. The objective of the government in a democracy is to $max\, U_m$, $U_e = U_e^c$.

2.2 Autocracy

Next we assume that the elite have successfully executed a coup and are in control of the country. They manage economic affairs so as to maximize their own welfare, subject to ensuring that the masses are sufficiently well off that they do not carry out a revolution. This is again a participation or consent constraint, this time to ensure the participation of the masses. The participation constraint for the masses is set by a similar equation to that used for the elite:

$$U_m^c = s_m U_m^* + (1 - s_m)\, U_m^l \tag{2.7}$$

where s_m is the success probability for a revolution initiated by the masses and U_m^*, U_m^l are respectively the welfare levels attained by the masses after successful and unsuccessful revolutions. The economic parameter controlled

by the elite is again the tax rate τ, chosen so that the masses achieve welfare level U_m^c. (In principle we have an inequality constraint here, $U_m \geq U_m^c$, but we assume it to be binding.) The tax rate affects the welfare of the masses via government spending, given as before by: $g = \tau If + \tau tR(1-P)$. Again the objective is to $max\, U_e$, $U_m = U_m^c$.

2.3 Equilibrium Analysis

In this section we show that the concepts of the previous sections can all fit together consistently. Recall that U_m^c and U_e^c represent the welfare levels associated with the consent constraints of the masses and the elite respectively: these are the welfare levels they have to attain if they are not to try and overthrow the system. These were defined in equations (2.5) and (2.7) above as $U_e^c = s_e U_e^* + (1-s_e)\, U_e^l$ and $U_m^c = s_m U_m^* + (1-s_m)\, U_m^l$. Here s_i is the exogenously-given probability of group i, $i = e, m$ overthrowing the system, and U_i^* and U_i^l are respectively the maximum welfare that party i can attain given the consent constraint on the other, and the welfare level resulting from a failed attempt to overthrow the system.

We let $U_m = F(U_e)$ be the formula for the utility possibility frontier relating the efficient welfare levels of typical members of the masses and the elite (figure 2.1). Clearly $U_m^* = F(U_e^c)$ and $U_e^* = F^{-1}(U_m^c)$. We also assume that the welfare level resulting from a failed attempt to overthrow the system is a known fraction $\lambda \in [0,1]$ of the welfare level from a successful coup, so that $U_m^l = \lambda U_m^*$ and $U_e^l = \lambda U_e^*$. Pulling all these observations together we have the following four equations

$$\begin{aligned} s_e U_e^* + (1-s_e)\, U_e^l &= F^{-1}(U_m^*) && (2.8)\\ s_m U_m^* + (1-s_m)\, U_m^l &= F(U_e^*) && (2.9)\\ U_m^l &= \lambda U_m^* && (2.10)\\ U_e^l &= \lambda U_e^* && (2.11) \end{aligned}$$

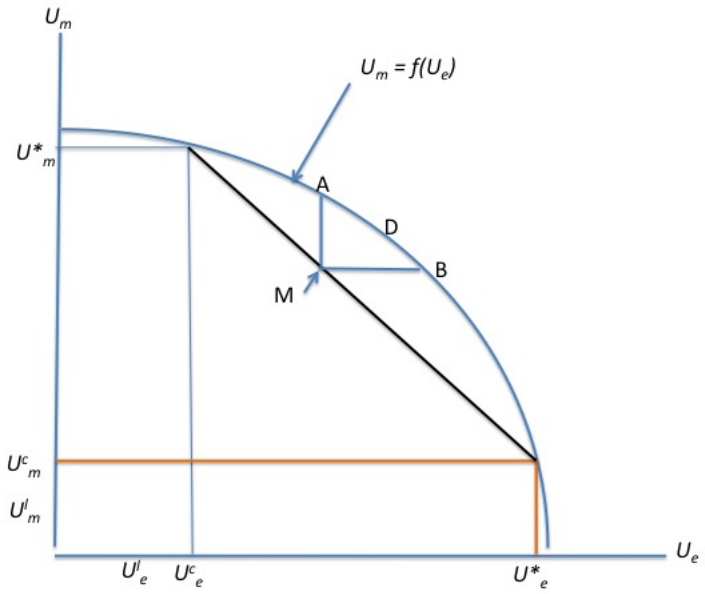

Fig. 2.1: The variables, $U^c_m, U^*_m, U^c_e, U^*_e$ and their relationships. $U^*_m = F\left(U^c_e\right)$ and $U^*_e = F^{-1}\left(U^c_m\right)$

which we can simplify to

$$s_e U^*_e + (1 - s_e)\,\lambda U^*_e = F^{-1}\left(U^*_m\right) \tag{2.12}$$

$$s_m U^*_m + (1 - s_m)\,\lambda U^*_m = F\left(U^*_e\right) \tag{2.13}$$

These are two equations in two unknowns, U^*_e, U^*_m . A solution will of course be a function of the parameters of the system, $s_e, s_m, \lambda, R, P, I, \tau, r, f, t$. Figure 2.1 shows these concepts and their relationships. While we cannot assert that this system of equations always has a positive solution, simulations for the cases of linear and circular utility frontiers indicate that it does for open sets of parameter values.

2.4 Comparative Statics

2.4.1 With Respect to P

We are now in a position to do some comparative statics analysis, looking at how the welfare levels of the two groups change with changes in permeability P, the fraction of resource rent accruing to the MNC. First consider the case of **democracy**, with the masses in control and facing the consent constraint (2.5). Recall that $g = \tau If + \tau tR(1-P)$. Suppose that P changes and that the welfare of the elite is kept constant at the initial constraint level U_e^c: this of course means holding the income of the elite constant. There is a choice to be made here: we can hold constant either total income or visible income. Holding total income constant is of course what the masses really want to do, but as not all income is visible they cannot be sure of doing this: they can however be sure of holding visible income constant. We investigate both cases, total income first. The total derivative of the (total) income of the masses I_m with respect to P is

$$\frac{dI_m}{dP} = \frac{\partial I_m}{\partial P} + \frac{\partial I_m}{\partial \tau}\frac{\partial \tau}{\partial P} \tag{2.14}$$

In this expression

$$\frac{\partial I_m}{\partial P} = -\tau tR, \ \frac{\partial I_m}{\partial \tau} = If + tR(1-P) \tag{2.15}$$

and the derivative of the tax rate with respect to P holding elite welfare constant is

$$\frac{\partial \tau}{\partial P}\,|_{U_e} = -\left\{\frac{-(1-\tau)\,tR/r - (1-t)\,R/r}{-\frac{tR}{r}(1-P) - I\frac{f}{r}}\right\} \tag{2.16}$$

so that

$$\frac{dI_m}{dP} = -R \tag{2.17}$$

Hence with elite welfare constant at its initial level the rate of change in government spending with permeability P equals the resource rent. We return to the implications of this below. If instead of keeping total income constant the rulers keep visible income constant, then we have

$$\frac{dI_m}{dP} = -tR \tag{2.18}$$

Next we investigate the other governance case, with the **elite in control** and facing a consent constraint from the masses (2.7). As before we can investigate the effect of a change in the fraction of resource rent going to the MNC. In response to such a change, the elite change the tax rate so as to keep the welfare level of the masses constant, so that $\tau \{If + (1-P)\, tR\}$ is kept constant. The total derivative of elite after-tax income with respect to P is

$$\frac{dI_e^a}{dP} = \frac{\partial I_e^a}{\partial P} + \frac{\partial I_e^a}{\partial \tau}\frac{\partial \tau}{\partial P} \tag{2.19}$$

and

$$\frac{\partial I_e^a}{\partial P} = -(1-\tau)\frac{R}{r} \tag{2.20}$$

$$\frac{\partial \tau}{\partial P}\,|_{U_m} = \frac{\tau t R}{r} \tag{2.21}$$

From this it follows that, when g is held constant,

$$\frac{\partial I_e^a}{\partial P} = -\frac{tR}{r} \tag{2.22}$$

There is an r in the denominator here because income released from taxation when net rent rises, given that the welfare of the masses is held constant, has to be expressed in per capita terms: this is not true in the democracy case as the public good, which is funded by taxation of the rent (amongst other sources) is available equally to all masses.

2.4.2 With Respect to $(1-P)\, R$

An alternative approach that gives slightly more intuitive and cleaner results is to conduct comparative statics with respect to the amount of resource rent that remains in the host country, $(1-P)\, R$. To do this we follow exactly the steps of the previous subsection, but instead of differentiating with respect to P we do so with respect to $(1-P)\, R = \bar{R}$. We can skip the technical details: the results are

$$\frac{dI_m}{d\bar{R}} = -1 \; or \; \frac{dI_m}{d\bar{R}} = -t \tag{2.23}$$

$$\frac{dI_e^a}{d\bar{R}} = -1 \tag{2.24}$$

In the first expression, giving the derivative of income of the masses, we have either -1 or $-t$ depending on whether actual income or visible income is held constant for the elite. Obviously if we have total transparency about income $t = 1$ then these are the same. So these equations are saying that with full transparency every extra dollar that does not leave the country goes to the ruling group, whether we have democracy or autocracy. Otherwise it is every extra visible dollar that goes to them.

2.5 Intuition

The rate at which the per capita income of the ruling group changes as permeability changes is essentially the same whichever group is in power: it is $-tR$, the total (visible) resource rent, in one case expressed in per capita terms. The rate at which the rent available to the home country changes with P is of course $-R$. In the autocracy case the elite are able to appropriate all of this extra rent for themselves. In the case of democracy, the masses also extract all the extra rent available to the home country themselves via an increase in government spending.

Why is the ruling group able to appropriate the entire extra rent available to the home country? Because of the participation constraints (2.5) and (2.7). These effectively specify income levels for the out-groups. These incomes do not change as permeability P changes, leaving all the extra resources available to the controlling group. Figure 2.2 illustrates this: the solid line shows a utility possibility frontier for representative members of the elite and the masses. In the case of democracy, the elite (whose welfare is on the horizontal axis) have to be given a welfare level of at least U_e^c, and clearly the best that the masses can do for themselves subject to this constraint is to attain their welfare level at the point on the frontier corresponding to U_e^c on the horizontal axis, shown as U_m^*. As permeability P changes, the utility possibility frontier moves in or out, as shown by the dotted lines, and the welfare attainable by the masses changes in response but the constraint on elite welfare is taken to be constant so that the masses absorb all the gains or losses from a change in permeability.

In the autocratic case the constraint is on the welfare of the masses, at the level shown as U_m^c, and the best that the elite can do is to pick the horizontal coordinate at the corresponding point on the frontier. Again changes in the frontier clearly affect the welfare of the ruling group and not that of the ruled, that of the elite and not that of the masses.

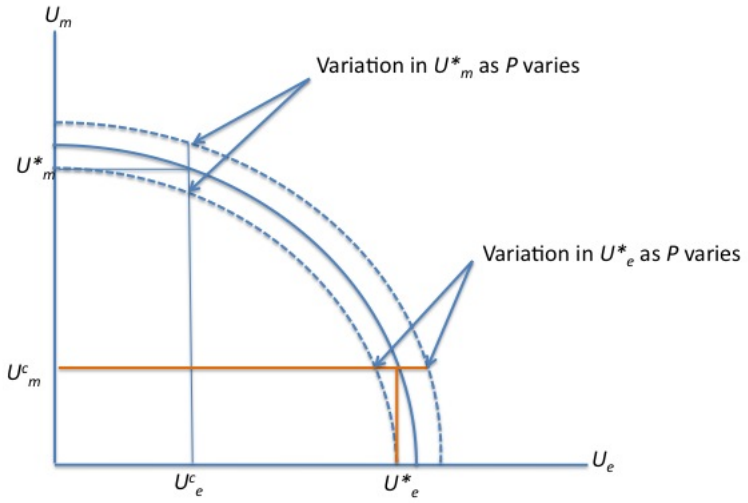

Fig. 2.2: The utility possibility frontier moves in response to changes in permeability.

This gives us insights into "how resource rents may shape economic conflict between elites and masses and thereby the emergence and persistence of democratic and authoritarian regimes." (Dunning (2008) page 63 of the Kindle version.) Changes in the amount of retained resource rent - permeability - feed directly into the income of the ruling class, whichever class this may be, giving them a very strong interest in this variable, and explaining why the political debate in resource-rich developing countries frequently revolves mainly around the negotiation and renegotiation of the terms on which MNCs exploit the country's resources, whoever is in power. By way of illustration, in Mongolia from 2007 to 2013 the top item of news in the English-language newspaper each week has been either the redrafting of the minerals law or the renegotiation of major mining agreements. (For more details and an illustration of this in the case of Zambia see Chichilnisky-Heal

2014.)

An obvious extension of the analysis would be to allow the participation constraints to alter with changes in permeability: we could imagine that the out-group's expectations from switching to a controlling situation rise as the available resource rent rises. In terms of figure 2.2, U_e^c and U_m^c would rise as the frontier moves outwards. Mathematically we would no longer differentiate with the out-group's welfare constant but with it in some functional relationship to resource rents available to the home country. In equations (2.5) and (2.7) the terms U_m^c, U_e^c would vary with the permeability.

We have taken transparency t to be exogenous, but it might be interesting and realistic to endogenize it. A first step could be to set $t = 1$ in the case of rule by the masses, reflecting the fact that once they are in charge they are well-placed to discover the full extent of resource-related income, but to allow $t > 1$ in the case of rule by the elite.

2.6 Pluralistic Governance

We have focused on two extreme cases, rule by the elite or the masses. There is another possibility, and in this case the effect of a change in permeability is quite different: incremental funds no longer accrue to the ruling group and there is no longer an incumbent advantage to a drop in permeability or a rise in the resource price. To understand this other possibility, consider figure 2.1 again. Suppose that on average the society is ruled by the elite a fraction τ of the time and by the masses for the remaining fraction $1-\tau$. Then for τ of the time it is at the point $\left(U_e^*, U_m^C\right)$ and the rest of the time it is at $\left(U_e^C, U_m^*\right)$, and let $M = \tau\left(U_e^*, U_m^C\right) + (1-\tau)\left(U_e^C, U_m^*\right)$. The point M represents the average welfare levels of the two groups over time as control switches from one to the other. M is clearly Pareto inefficient:[2] both could be made better off at any point on the utility possibility frontier between A and B. The two groups should be able to bargain to reach a point such as D in this interval, as both gain by such a move. In this case there is no presumption that as the frontier moves in or out because of changes in permeability or prices or other external parameters, all benefits will accrue to one group: the distribution of gains will depend on the details of the arrangement used to select and support the point D.

[2] The inefficiency arises from risk aversion and not knowing what the welfare level will actually be at any point in time.

3 The Host and the MNC

To understand the relationship between the host country and the MNC and to generate any interesting predictions about the value of P we need a framework with more structure. To provide this we model the relationship between them as the equilibrium of a non-cooperative game (in the next subsection we investigate the implications of a bargaining approach).

We assume that the total rent available is a function of two variables, the permeability P, which is chosen by the host country, and the investment I in developing the resource deposits, which is chosen by the MNC. The outcome also depends on the stage of development of the host country, which is exogenous and is represented by D. The investment in resource development is chosen by the MNC in response to the financial terms offered to the it, represented by permeability P, so $I = I(P)$. And the rent available is a function of the investment and the stage of development, $R = R(I(P), D)$. For a given level of development D, we assume the total rent available R is an increasing concave function of the permeability, reflecting the fact that greater payments to the MNC give it more incentive to prospect for resources and to invest in their discovery and extraction, but that there are diminishing returns to this process. So the curve $R(I(P), D)$ shows the rent resulting from the MNC's best response to the level of permeability P offered by the host. And for a given level of permeability, i.e. a given incentive structure, the total rent available increases with the level of development. More developed countries have better infrastructure, a better qualified labor force, and can manage the resource extraction process more effectively.

Figure 3.1 shows this set of relationships: permeability P is plotted horizontally and total rent R vertically, and the three labelled brown lines show how total rent available $R(I(P), D)$ increases with P for a given level of D, and also increase with D for a given P. The rent accruing to the host country is $(1 - P) R(I(P), D)$. We simplify the expression for rent to $R(P, D)$.

It seems natural to think of the host as initiating discussions with an MNC and trying to anticipate how this will react to terms offered by the host, so we use a Stackelberg leader-follower framework, with the host as the leader.[3] The host proposes a value for permeability P, and the MNC responds with a value for investment I which maximizes the MNC's net revenues and which

[3] An analysis based on the more symmetric Nash equilibrium concept does not lead to interesting insights in this problem.

for a given stage of development D implies a rent $R\left(I\left(P\right),D\right)$: this function is the MNC's reaction function to the host's choice of strategy P. The host is assumed to know this reaction function and so will choose P so as to maximize its receipts from the resource given the MNC's reaction function. That is, it chooses P to maximize $\left(1-P\right)R\left(I\left(P\right),D\right)$. Maximizing this with respect to P leads to

$$-R\left(P,D\right)+\left(1-P\right)\frac{\partial R}{\partial P}=0\ or\ \frac{R}{1-P}=\frac{\partial R}{\partial P} \tag{3.1}$$

as a first order condition. Here $\partial R/\partial P$ is the slope of the curve $R\left(P,D\right)$ and $R/\left(1-P\right)$ is the slope of the rectangular hyperbola on which host revenues are constant $\left(1-P\right)R$, which has its horizontal axis increasing to the left. These are the convex curves in figure 3.1. The tangencies shown meet this condition, and the locus of such points of tangency will move upwards and to the left as D increases, as shown. These are optima for the host and represent a tradeoff between the loss of rent from greater permeability and the increase in rent because greater permeability provides stronger incentives to the MNC. Each point of tangency between a contour of the host country's payoff and a rent-permeability curve for a given level of development is a Stackelberg equilibrium in the game between the host and the MNC for a given level of development D.

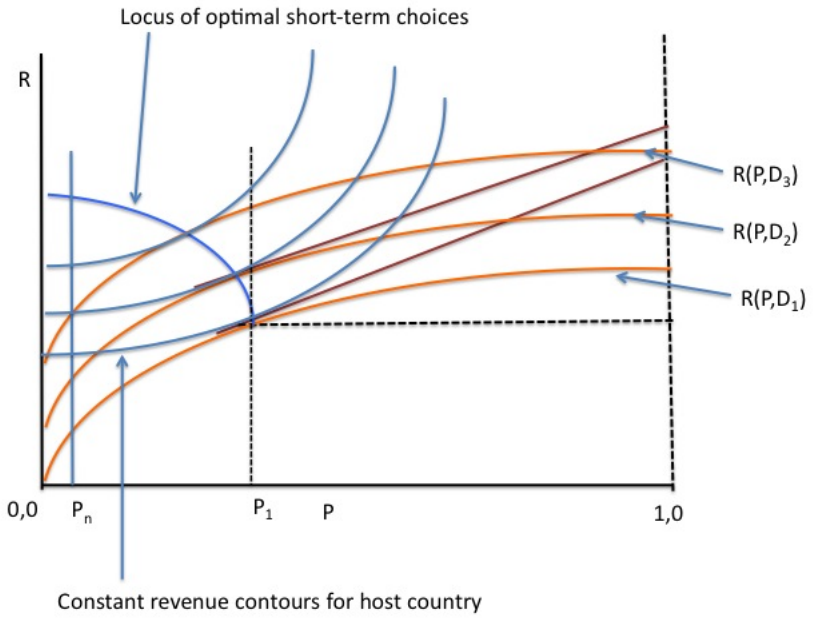

Fig. 3.1: The host's optimal bargain changes with the level of development and follows the locus of points of tangency.

If the host country's development level were D_1 then the best level of permeability for the host country would be P_1, but if the level of development were to increase, as it presumably will over time, the best choice of P will fall, as shown by the locus of optimal short-term choices. This poses a dilemma for the host country: at development level D_1 should it choose permeability P_1, which is currently optimal, or should it choose a lower level which will be optimal at some future level of development? If so, optimal at which future stage of development? The core of the problem the host country faces is that it knows that any choice which seems optimal under current circumstances will seem suboptimal at future dates with higher development levels. A sequence of choices of P, each of which is the best choice at the time it is made, is not time consistent: all these choices will seem wrong at later dates and the host country will wish to revise them. If the host country chooses P_1 and then stays with this, it will move over time up the vertical line through P_1, and at future dates the chosen level of permeability will seem too high.

A way of resolving this conundrum is to think of the host country's problem as a dynamic optimization problem, in which it seeks to choose permeability at each point in time to maximize the present value of revenues:

$$Max_{P(t)} \int_0^{\infty} (1 - P(t)) R(P(t) D(t)) e^{-\delta t} dt \tag{3.2}$$

where $\delta \geq 0$ is a discount rate, the level of development $D(t)$ is an exogenous function of time, and $P(t)$ is the variable whose time path is to be chosen. The solution to this problem simply requires that P be chosen at each date to satisfy the first order condition (3.1), which means following the locus of points of tangency upwards and to the left in figure 3.1. If the level of development $D(t)$ is made endogenous, so that D increases with the rent received, then the solution is qualitatively the same, except that the rate of movement may be different. (For a full mathematical treatment see Appendix 1.)

Suppose then that the host country seeks to do what is optimal for it and revise the level of permeability at each stage of development, following the locus of short-term optima; what is the outcome? The problem here is that there are two parties to any bargain, the host country and the MNC. The MNC will wish to hold the host to the initial high level of permeability, and will not agree to revisions that worsen the terms it faces. So there is a fundamental conflict between what the host and the MNC want, which in fact becomes sharper over time as the host moves to higher levels of development and seeks to move to the left in figure 3.1 and reduce the payments to the MNC.

Many agreements between hosts and MNCs anticipate precisely this conflict. For example, in 1997 Mongolia introduced the Minerals Law, described by the United States Geological Survey as the most liberal mineral law in the world at the time. This law made provision for "stability agreements," which guarantee that the terms negotiated between the host and the MNC will not be changed for some specified period - 20 to 60 years are typical. According to an authority on these agreements,

> "Mining and petroleum agreements governing the exploration and development of natural resources frequently include contractual assurances of stability. These stability clauses are intended as legally binding commitments by the host country's government. The commitment may be for an initial period of years or for

> the length of the agreement. They may cover a broad-range of host country laws or be limited to fiscal laws or even certain provisions in the fiscal laws, such as tax and royalty rates. ..... Fiscal stability clauses are generally justified by: (1) the large size and the sunken nature of the initial investment, and (2) often a long period required to recover investment and earn a reasonable return, taken together with (3) a lack of credibility on behalf of the host country to abstain from changing the fiscal rules – possibly singling out high rent petroleum or mining operations – once the investment is sunk (the "time inconsistency problem").[4]

In fact it is not unusual for mining contracts to be negotiated in an ad hoc fashion outside of the country's mineral laws, with dispute settlement clauses that disempower the host country's domestic courts, and with the MNC being explicitly exempted from any subsequent changes in the host country laws. Bilateral investment treaties institutionalize this idea as does the Energy Charter Treaty in the case of petroleum-exporting countries (van Benthem and Stroebel (2013b)). A particular source of conflict has been the introduction of environmental laws in countries where there were initially none, with mining MNCs - often the main polluters - being exempt from these. The issue here is that the host country cannot credibly commit to an agreement that it will clearly wish to change, and has to resort to invoking authorities outside the country.[5]

This conflict of interests describes precisely the situation in reflected in figure 3.1: it is clear that the host country will wish to revise any constant P agreement that it signs early in its economic development, to the disadvantage of the MNC, because a choice that looks optimal today will not seem so in a decade. Although Mongolia introduced a pro-MNC legal regime in 1997, it has since drastically changed its mining laws, introducing a windfall profits tax in 2006. (The agreement that Mongolia initially signed with Centerra Gold provided for no income tax liability for ten years.) Zambia, another resource-rich poor country, followed suit in 2008: both were attempting to capture some of the extra rents generated by the resource price boom of the early 2000s. It has often been the case that international financial institutions, when negotiating with the host country about economic assistance

[4] See https://www.international-arbitration-attorney.com/wp-content/uploads/arbitrationlaw1394930.pdf#page=422, Daniel and Sunley (2010)

[5] See Radon (2007), who refers to "contractual colonialism."

programs, seek concessions concerning the legislative framework for extractive activities, promoting stability agreements amongst others and, in accord with the Washington Consensus, promoting the interests of the MNCs.

The quote above also hints at another aspect of the bargaining situation, namely the fact of large sunk costs in mining operations. The MNC has to make substantial irreversible investments before any revenues flow from the project, and so is vulnerable to exploitation by the host via a strategy that offers attractive terms before the investment is made and revised these once it is in place and cannot be undone.

These observations are all consistent with the "obsolescing bargain model,"[6] which suggests that host countries naturally strike bargains that become sub-optimal for them, although the mechanism through which sub-optimality emerges is rather different here: the obsolescing bargaining literature focuses on changes in rents due to changes in prices as a driver of dissatisfaction with existing deals (as in the cases of Mongolia and Zambia with windfall profits taxes cited above). The model presented here can be thought of as providing an analytical underpinning for and an extension of the obsolescing bargain model. The discussion of bargaining and the holdup problem in the next subsection provides further insight into the idea of an obsolescing bargain between host and MNC.

4 The Holdup Problem in Host-MNC Relations

The central problem in reaching a stable and efficient relationship between the host and the MNC is an illustration of the hold-up problem (see Tirole (1986) or Hart (1995)). The host country is selling to the MNC the right to produce its resource and sell it on world markets. To take advantage of this offer the MNC must make a substantial investment that is specific to this trading relationship, and that has no value in any other context. The two parties agree terms before the investment is made, and on the basis of this agreement the MNC executes the investment, generally in the multi-billion dollar range. Once the investment is made, the host may reopen the bargaining process and the MNC's bargaining power is then greatly reduced, as it already has a financial commitment to the relationship, something that both parties can anticipate in advance. A simple model illustrates this point.

[6] See for example Moran (1978).

Assume that the MNC can invest an amount I in the host country to generate profits of $\pi(I)$ and that the investment costs kI. Obviously the optimal investment level I^* satisfies the first order condition $k = \frac{\partial \pi}{\partial I}$. Before any investment is made, the two parties bargain about how to share the profits generated, and agree that the MNC will receive a share P, with $(1-P)$ going to the host country. Maximizing $P[\pi(I) - kI]$ is the same as maximizing $\pi(I) - kI$ so the MNC will still choose the socially optimal investment level. Assume the bargaining process that leads to this agreement on how to divide the profits is a Nash bargaining process, so that P is the sharing rule that maximizes the product of the differences between the host's and MNC's welfare levels and their fall-back points, the welfare levels they attain in the event of no agreement. In the event of no agreement neither makes any profit or incurs any costs, so the fall-back point is at the origin. If the utility functions are identical then the outcome will be symmetric and we will have $P = 0.5$.

Now suppose that the parties reach an ex ante agreement on profit-sharing, a value of P, and on the basis of this the MNC makes the investment I^*. Once the investment is made and the associated costs are sunk, the host reopens the bargaining process and there is a further round of Nash bargaining. In this case in the event of no agreement the MNC loses its investment I^*, and the host country gains this. So the fall-back positions are no longer equal. A new round of Nash bargaining will lead to a smaller share of profits going to the MNC: this is the essence of the hold-up problem (see Appendix 2 for detailed arguments). The stability agreements discussed above are a response to this, but they are generally inadequate. Bilateral investment treaties are a more sophisticated attempt to grapple with the same issues and are more successful, but have not prevented expropriations (van Benthem and Stroebel (2013a)).

A response to hold-up problems widely considered in the industrial organization literature is to integrate the two parties to the problem. It is clearly not possible to integrate the host country and a multinational corporation, and the nearest one could come to this in the present case would be to set up a new company whose sole purpose is to produce and sell the resource from the host country. This company would be jointly owned by the host and the MNC, and profits would be shared between them according to their shareholdings (for more discussion of integration see Che and Sákovics (2004) and Bolton and Whinston (1993)). However, in the present context this would not overcome possibility of holdup. The nature of such a deal would be that

the host would give the jointly-owned company mineral development rights in exchange for shares, and the MNC would provide capital and technology in exchange of its shares. Once such a deal was in place and the investment had been carried out by the MNC, the host would as before be in a position to reopen negotiations and threaten the MNC with the loss of its right to operate and so of its investment if it failed to agree a larger shareholding for the host.

It seems that the potential for holdup is very deeply embedded in the structure of host-MNC relations, leaving the MNC vulnerable to a loss of anticipated revenues from the venture. One reason for this is that the relationship is between a sovereign state and a foreign corporation. They can choose which legal system will govern their relationship - New York, London, etc. - but none of these jurisdictions have power to inflict substantial penalties on the host in the event that it violates the agreement. So even elaborate agreements with complex stability clauses, as discussed above, cannot ensure that the host will not at some stage reopen negotiations.

There are some events which tend to trigger a reopening of negotiations, and one way of avoiding such reopening is to specify in advance how terms of the contract may be modified if these triggers occur. For example, the price of the commodity being mined may rise, making the initial contract far more profitable for the MNC than the host had anticipated. Several authors studying the hold-up problem have shown that hold-ups triggered by unanticipated events can be avoided by specifying how the contract can be modified if such events occur (Bolton and Whinston (1993), van Benthem and Stroebel (2013b)).

One option that must appeal to the MNC is to try to ensure that the host government is friendly and not disposed to reopen negotiations. There are clearly several routes to this. One is intervention in the domestic affairs of the host to influence political outcomes. This might involve supporting a party or politician seen as well-disposed, or assembling a group of supporters by what in game theory are described as side-payments, and in this context would surely be seen as bribes. This could be a factor contributing to the observation that political processes in many resource-rich countries are corrupt (Ross (2013)). Another route to a favorable political orientation in the host country is to persuade third parties to use influence over the host to ensure that it does not exploit its bargaining power. Natural allies would be international financial institutions, particularly those on which the host country might have some dependence such as the World Bank or a regional develop-

ment bank, or the MNC's home government, which could be lobbied to make aid disbursements conditional on a suitable financial settlement between the host and the MNC. There is anecdotal evidence at least that all these options are used by resource-extraction MNCs: Chichilnisky-Heal (2014) refers to the use of World Bank influence in Mongolia and Zambia to attempt to prevent the government from reopening contractual terms. The second author has personal experience of a similar situation in Papua New Guinea. This issue continues to be topical: a headline in the Financial Times recently stated "Cash-strapped Nigeria to renegotiate contracts with oil majors," showing that the hold-up problem does not diminish over time.[7]

4.1 Adoption of Bilateral Investment Treaties

As we have mentioned an increasingly common response to the hold-up problem implicit in host-MNC relations is for the host country to sign a Bilateral Investment Treaty. BITs are a way for a host country to commit itself to following certain procedures and staying within the scope of agreements. BITs are typically between a developing country that is potentially the host of investment and the home government of an MNC that might invest in the host, or the government of a country in which the MNC does business. These treaties involve an intergovernmental agreement that covers all aspects of investment, and typically includes provisions for international arbitration in the event of a dispute. Such provisions mean that when a host country that has signed a BIT with the home country of an MNC also signs an agreement with the MNC, this represents a commitment that cannot readily be altered or disregarded. BITs have become widespread in the last few decades, and a natural question is why a developing country would sign a treaty that limits its ability to exploit its bargaining power in the future. A part of the answer is clearly that this is seen as a prerequisite to obtaining more foreign investment, but this possible increase comes at a cost.

One of the most interesting observation on this question was suggested by Guzman (1997), who makes the argument that poor countries sign bilateral investment treaties (BITs) because of competition with other poor countries. One country signs initially and this diverts investment from others to it,

[7] Financial Times, posted online at 7.14pm, September 15 2015. According to the FT, 'The NNPC said it would overhaul its contracts with companies such as Shell, Chevron, Eni and ExxonMobil "in the weeks and months ahead...to extract as much benefit as possible for Nigeria."'

giving the others an incentive to sign too, and this competition then leads to them all signing and makes them all worse off in the end. Dixit (2003) refers to a process like this as "entrapment." Guzman sees the structure of the game between them as something like a prisoners' dilemma game, with the best outcome for all poor countries being that none signs a BIT, but each having an incentive to defect from this equilibrium if they assume all others are going to continue in it.

Bubb and Rose-Ackerman (2007) model this idea slightly differently: they assume that the gains to a poor country from signing and not signing are both decreasing functions of the number of poor countries that have already signed, and then look for Nash equilibrium patterns of signing/not signing. They assume that all countries signing is a Nash equilibrium, that all not signing is not, and analyze when there may be intermediate equilibria.

Here we work with a rather different framework. We assume that there are at least two possible Nash equilibria to the game between poor countries when they are choosing whether or not to sign. One is that all sign, as with Bubb and Rose-Ackerman: the other is that none sign. So we are making an assumption that all not signing is an equilibrium, which neither Guzman nor Bubb and Rose-Ackerman do: in this sense we are making not signing more stable, making it more difficult for the process of some countries signing to force others to sign. The point is not that this is a good description of reality, but rather that even if not signing were to be a stable situation, it would still be the case that some countries deciding to sign can force all others to sign and that all will be worse off as a result of this than if none had signed.

Assume there are N developing countries indexed by $i = 1, ..., N$ trading with a set of rich countries and considering signing bilateral investment treaties with them. Each developing country has two strategies - to sign a BIT with the rich countries $S_i = 1$, or to decide not to sign, $S_i = 0$. Payoffs are a function of all agents' strategies and we write them $U_i(S_i, S_{-i})$ where S_{-i} is the vector of strategies of all agents other than agent i. We order strategy vectors $S = (S_i, S_{-i})$ by the usual vector ordering, so that $S' > S$ means that $S'_i \geq S_i \, \forall i \, \& \, \exists j \, : S'_j > S_j$.

We assume the payoffs show what Heal and Kunreuther call uniform strict increasing differences, which means that $\exists \epsilon > 0$ such that if $S'_{-i} > S_{-i}$ then

$$U_i\left(1_i, S'_{-i}\right) - U_i\left(0_i, S'_{-i}\right) \geq \epsilon + U_i\left(1_i, S_{-i}\right) - U_i\left(0_i, S_{-i}\right) \tag{4.1}$$

where $0_i, 1_i$ represent a zero or a one as the $i-th$ component of the vector. In intuitive terms this just says that decisions to sign BITs are strategic com-

plements. The payoff to changing from not signing 0_i to signing 1_i increases as the number who have already signed gets larger. This is consistent with the case argued by Guzman and Bubb and Rose-Ackerman: every time another country signs a BIT it takes investment away from those who have not signed and increases their incentive to sign. This could be because the payoff to signing increases, or that to not signing decreases, or some combination.

In order to explain our result, we need some additional definitions. A tipping set is a subset of the developing countries, which we will denote $T \subset S$, with the property that if these countries choose to sign a BIT, then all others find this to be their best move also. Formally, if $S_i = 1 \forall i \in T$, then $\forall i \notin T,\ U_i(1_i, S_{-i}) \geq U_i(0_i, S_{-i})$. So if all poor countries are initially not signing BITs and then those in T change and decide to do so, the best move for all others is now to sign too. In this sense the members of Tcan "tip" the system from no countries signing BITs to all doing so. The result we are able to prove is that provided there are enough developing countries (N is large enough), there is always a tipping set with fewer than N countries in it.

Proposition 1. *Under the assumption (4.1) of increasing differences, and with a large enough number N of developing countries, there is a tipping set T with fewer than N-1 members that can tip the equilibrium where no country signs a BIT to one where all sign.*

This is an immediate application of Heal and Kunreuther (2010).

Intuitively this result is driven by the increasing differences condition, which ensures that choices to sign BITs are strategic complements. A numerical example will perhaps be helpful in conveying how this works. Suppose that there are ten players ($N = 10$), each of whom may sign or not ($S_i = 1$ *or* 0). The payoffs to these choices are $U_i = 9\ if\ S_i = 1,\ U_i = \#(0)\ if\ S_i = 0$. Here $\#(0)$ is the number of countries choosing strategy 0, i.e. the number choosing not to sign. So if all countries do not sign, they all get a payoff of 10. And if one were to change to signing and the others remained as before, the payoff to the signer would be 9, so there is no incentive for anyone to change from 0 to 1 when all are at 1: all choosing 1 is a Nash equilibrium. And if all choose to sign, then they all get a payoff of 9: any country that moves from 1 to 0 when the rest are at 1 will get a payoff of 1, so all signing is also a Nash equilibrium. Now suppose that all countries are not signing, $S_i = 0 \forall i$, and then two - any two - choose to change to signing. Then the payoff to any other country that joins them is 9 and the payoff to remaining a non-signer is 8. Hence all countries will now join the initial two

and sign. The first two to sign have in effect forced the remainder to sign, not forced in a legal or physical sense, but forced in the sense of changing the incentives facing them so that their best move is now to sign. When all sign they will all get a payoff of 9: when none signed they all got a payoff of 10. So the first movers have forced the rest into a move which results in all being worse off.

In the context of the game, there is no reason why any country should move from the equilibrium where all are not signing BITs, which is an equilibrium - this is a difference between our model and that of Bubb and Rose-Ackerman. But if we place the game in a broader geopolitical context there are many explanations. For example, the leaders of the first countries to sign may gain personally from the existence of a BIT, or some of their supporters may. Alternatively, the rich countries, seeking to break an implicit cartel of non-signing countries, may offer some incentives outside the game, such as aid, military assistance or access to advanced military hardware, etc.

4.2 Investment in Resource-Rich LDCs

The work of Guzman and Bubb and Rose-Ackerman gives us some fundamental insights into the driving forces behind the expansion of BITs. Central to these models is the idea of competition between LDCs for investment from rich countries. Such competition is a reality in many cases: if all an LDC has to offer to potential investors is low wages, then the terms on which FDI is managed will be an important factor in locational choices of investors. There are many poor countries offering low wages to labor-intensive industries and none will have particular market power. But the same is not true of resource-rich countries: there are few resource-rich countries and many MNCs that would be happy to develop their resources. If a country really has rich reserves of a valuable mineral, MNCs are not so sensitive to the terms on which they can invest. As an example, consider the willingness of western oil companies to invest in Russia, a country where the risks of expropriation are above the average. In the case of investment in resource-rich countries we are closer to a bilateral monopoly when it comes to thinking about the relations between host and MNC. Indeed the situation may be closer to a monopoly supplier of the resource facing competing buyers of the right to develop it. Most oil-rich countries choose to develop their reserves through national oil companies, sometime working in collaboration with international oil majors, and obtain very favorable terms for their resources (van Benthem

and Stroebel (2013b)). The literature on BITs probably needs to differentiate between resource-rich and other developing countries.

5 Conclusions

We have investigated various aspects of the relationships between resource-rich developing countries and multi-national corporations that develop their resources. We began by considering the role of permeability, in the sense of the fraction of resource rent leaving the country, in domestic politics, showing that a decrease in permeability will always benefit the ruling group, whether the country is a democracy or an autocracy.

We then modeled the determination of permeability through games between the host and the MNC, and noted that there is a fundamental problem in reaching a stable agreement that both parties are happy with. In a non-cooperative framework the host will always view an agreement reached at an earlier date as sub-optimal and want to revise it - as indicated by the obsolescing bargain literature, though for rather different and more fundamental and structural reasons. The obsolescing bargain literature sees the need for revision as coming from changes in external parameters such as prices: we indicate that this need is built into the structure of the problem. The discussion of bargaining and the hold-up problem in host-MNC relations emphasizes the point that the obsolescence of an initial bargain is guaranteed even if there are no changes in external parameters. The fundamental role that the possibility of hold-up plays in the relationship between the host and the MNC suggests strong incentives for the MNC to influence domestic politics in the host, possibly making the host's political system permeable in a broader sense.

A way of resolving the hold-up problem is for the host and the home country of the MNC to sign a BIT that places restrictions on the host's ability to alter the terms of an investment deal once it has been agreed. The signing of a BIT means that the host is committing itself when it makes a deal with an MNC: it is throwing away some of its bargaining power. One might expect that this would happen only when there is a clear net gain from doing this, perhaps in terms of more investment being available because of the security implied by the BIT. However, Guzman has suggested that countries can be "entrapped" (using Dixit's words) into making agreements that in the end make them worse off, and we have developed that point as an application of

the theory of tipping sets in games of strategic complementarity. If a subset of poor countries sign BITs with investor countries, them may in effect force their peers to follow suit, and in the end produce an equilibrium where all poor countries are worse off than if none signed BITs.

6 Appendices

6.1 Appendix 1

Above we considered the problem

$$Max_{P(t)} \int_0^{\infty} (1 - P(t)) R(P(t) D(t)) e^{-\delta t} dt$$

which involves choosing permeability at each date so as to maximize the present value of revenues accruing to the host country. Here $\delta \geqq 0$ is a discount rate and $D(t)$ is the time path of development, which we take as exogenous for the present. To solve this problem we choose $P(t)$ so as to maximize the Hamiltonian

$$H = [1 - P(t)] R[P(t) D(t)] e^{-\delta t}$$

at each time t, which gives as a first order condition

$$R(t) = (1 - P(t)) \frac{\partial R}{\partial P}$$

which is the same as equation (3.1) above. A more complex version of this approach is to endogenize the level of development as a function of cumulative revenues generated from the resource. This would give a state variable

$$D(t) = \int_0^t [1 - P(\tau)] R(\tau) d\tau \tag{6.1}$$

and its rate of change

$$\frac{dD}{dt} = [1 - P(t)] R(t) \tag{6.2}$$

The Hamiltonian is now

$$H == [1 - P(t)] R[P(t) D(t)] e^{-\delta t} + \lambda e^{-\delta t} [1 - P(t)] R[P(t) D(t)] \tag{6.3}$$

The first order condition is again

$$R(t) = (1 - P(t)) \frac{\partial R}{\partial P} \tag{6.4}$$

so that the analysis of figure 3.1 again applies and an optimal path involves following the locus of points of tangency.

6.2 Appendix 2

Let $U_h((1-P)R)$ and $U_m(PR)$ be the utilities of the host country and the MNC respectively, with $P \in [0,1]$ the fraction of total revenue accruing to the MNC. The two parties engage in a Nash bargaining process to choose P. Ex ante, before any investment is made, their fall-back positions, their payoffs in the event of no agreement, are both zero: neither party makes or looses money in the event of no agreement. Hence the Nash bargaining solution satisfies

$$\underset{P}{Max} \{U_h((1-P)R) - 0\} \{U_m(PR) - 0\} \tag{6.5}$$

the solution to which requires that

$$\frac{U_h'}{U_h} = \frac{U_m'}{U_m} \tag{6.6}$$

If both payoff functions are identical, an assumption we make to allow us to focus on the factors essential to our argument, then this implies that $P = 0.5$.

Now assume that parties are bargaining again after the MNC has made an investment of I, perhaps because the host has forced a reopening of the terms of their agreement. In this situation, the MNC stands to loose its investment in the event of no agreement. The Nash solution therefor now satisfies

$$\underset{P}{Max} \{U_h((1-P)R) - 0\} \{U_m(PR) - I\} \tag{6.7}$$

and the first order conditions are now

$$\frac{U_h'}{U_h}\left[1 - \frac{I}{U_m}\right] = \frac{U_m'}{U_m} \tag{6.8}$$

We know that I represents an amount that is lost, so $I < 0$ and

$$\frac{U_h'}{U_h} < \frac{U_m'}{U_m} \tag{6.9}$$

We can also show that

$$\frac{d}{dx}\left[\frac{U(x)'}{U(x)}\right] < 0$$

under standard concavity conditions on the payoff functions, so it follows that $P < 0.5$.

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