Implications of Trade and Institutions for Resource Management

Florian K. Diekert
(f.k.diekert@bio.uio.no)

Overview

While trade liberalization is beneficial under optimal management (it removes a binding constraint), this is not necessarily the case under open access. So far, property right regimes have been treated as exogenously given. Yet, when they depend on deeper country characteristics, one may end up in a situation where a price shock leads one country to adopt optimal management practices and reap the gains from trade, whereas another country fails to do so and rents continue to be dissipated. The first lecture will be concerned with models that illustrate these issues.

These aspects are usually discussed in the context of renewable resources, but there is a related discussion with respect to non-renewable resources: Some countries (e.g. Nigeria, Venezuela, Saudi Arabia) remain relatively poor, in spite of their rich endowment with resources, while some countries (Norway, Botswana, Malaysia) have experienced strong GDP growth. In the second lecture, an overview of the potential causes of the "resource curse" will be given. A model which highlights one particular mechanism, but ties nicely with the previous discussions of the Hotelling and Hartwick rules, will be presented. Finally, we take a look at the empirical evidence.

This note presents simplified versions of the models in Copeland and Taylor (2009) and van der Ploeg (2010). Additionally, you are directed to the references at the end. In particular Bulte and Barbier (2005) and Deacon (2010) give good overviews for renewable and non-renewable resources, respectively. Demsetz (1967) is a classical paper on the theory of property rights.

1 Trade, Tragedy, and the Commons

Usually, the polar cases of optimal management and open access are analyzed, where the institutional setup is treated as exogenously given. But surely, real world situations are intermediate case, and the institutional setup is not necessarily static. Broadly, "institutions" are understood as the rules of the game, but here it is important to distinguish between country characteristics, and property right regimes. It is plausible to argue that the former may not change (or only very slowly), but the latter may change (possibly quite suddendly) in response to e.g. trade liberalisation, technological changes or population growth.

1.1 Model

The following is a simplified version of the model presented in Copeland and Taylor (2009). The bio-economic model is of the standard Gordon-Schaefer type, equation (1) and (2), and the focus is throughout on the steady state $G(S) = H$.

$$G(S) = rS\left(1 - \frac{S}{K}\right) \tag{1}$$

$$H = \alpha LS \tag{2}$$

implying that in steady state:

$$S = K\left(1 - \frac{\alpha L}{r}\right) \tag{3}$$

Effort L is the aggregate labour devoted to harvesting the renewable resource. Total population size is N and the alternative occupation is manufacturing, a CRS technology which pays w per unit of labour. The individual household thus has the following revenue:

$$R = p\alpha lS + (1 - l)w \tag{4}$$

Now we make two assumptions to get the story started: First, at high stock levels, resource rents are positive:

$$\pi^C = p\alpha S - w > 0 \quad \text{for some } S \leq K \tag{A-1}$$

At high stock levels, everybody would like to spend his or her entire time harvesting the resource. However, the second assumption is that there is overcapacity in the sense that if everybody were to harvest, the stock would be extinguished. That is:

$$\frac{\alpha N}{r} > 1. \tag{A-2}$$

Hence there are rents to be had, if the manager would succeed in restraining harvesting effort. However, there is only imperfect monitoring and enforcement. All the manager can do is to announce an individual effort level l and devise a scheme where the individual household is banned from harvesting if caught cheating. Denote the lowest level to which effort can be restraint in this way by L^T. Obviously the level of L^T will depend on country characteristics, in particular on ρ, the probability to detect cheaters, on δ, the discount rate, and on the population size.

The precise derivation of L^T in Copeland and Taylor (2009, p.370-372) is interesting in itself, but not the focus of this lecture. For the present simplification, it is sufficient to note that, in equilibrium, the individual equates the fine F from cheating, weighted by the probability of being detected ρ, with the instantaneous gains from cheating:

$$\rho F = \pi^C - \pi \tag{5}$$

where π is the return to behaving (harvesting with the individual effort level l, i.e. $\pi = p\alpha lS - wl$). The fine F is set equal to the annuity of being excluded from harvesting the resource, which in steady-state is $F = \frac{\pi}{\delta}$. Aggregate effort is given by $L = N \cdot l$, so that the lowest level to which effort can be restraint is[1]

$$L^T = \frac{\delta}{\delta + \rho} N \tag{6}$$

It is however not necessarily the case that the manager always enforces the effort level L^T. On the one hand, it is possible that L^T is so high compared to the value of the resource, that employing L^T would imply negative rents. The best that the manager can do in this case "is to throw up his hands and allow agents to harvest all they want". Effort will enter until all rents are dissipated (the revenue from time spent harvesting equals its opportunity cost from time spent in manufacturing), denote this level L^{OA}.

$$L^{OA} = \frac{r}{\alpha}\left(1 - \frac{w}{p\alpha K}\right) \tag{7}$$

On the other hand, it is possible that the resource is so valuable that the first-best optimal level of effort L^* is higher than L^T. In other words, L^* is the (interior) result of an unconstrained maximization of $\int_0^\infty [p\alpha LS + w(N-L)]e^{-\delta t}\mathrm{d}t$ subject to (1). It is implicitly defined by the familiar relationships:

$$\delta = G'(S^*) + \frac{\alpha L^*}{p\alpha S^* - w} \quad \text{(a)} \qquad \text{and} \qquad L^* = \frac{g}{\alpha}\left(1 - \frac{S^*}{K}\right) \quad \text{(b)} \tag{8}$$

As a result, the resource manager is faced with the following "incentive constraint":

$$L \geq \min\{L^{OA}, L^T\} \tag{9}$$

Note that while L^T is independent of the price p, the open access level of effort L^{OA} and the unconstrained first-best level of effort L^* are increasing in p. As p grows very large, $L^{OA} \to \frac{r}{\alpha}$ (confer equation 7) and $L^* \to \frac{r+\delta}{2\alpha}$. The latter can be deduced from the fact that as the price rises without bounds, the resource becomes so valuable that the stock-effect in the cost function loses its significance, and condition (8a) simplifies to $\delta = G'(S^*) = r - \frac{2r}{K}S^*$, which can then be substituted into (8b).

[1] Inserting $F = \frac{\pi}{\delta}$ in (5), using $\pi^C = \frac{\pi}{l^*}$, and canceling π yields: $\rho F = \pi^C - \pi \quad \Rightarrow \quad \rho\frac{\pi}{\delta} = \frac{\pi}{l} - \pi \quad \Rightarrow \quad \frac{\rho}{\delta} = \frac{1}{l} - 1 \quad \Rightarrow \quad \frac{\delta+\rho}{\delta} = \frac{1}{l}$

If the incentive constraint (9) binds, de facto open access will result when $L^T \geq L^{OA}$. *Hardin economies* are characterized by $L_H^T \geq \frac{r}{\alpha}$, so that they never resolve their "tragedy of the commons", irrespective how valuable the resource is.

For *Ostrom economies*, $L_O^T < \frac{r}{\alpha}$ so that there exists a price p^+ for which harvesting restrictions are successfully implemented and rents are being generated. However, the enforcement power of Ostrom economies is not sufficient to achieve the first-best, that is $L_O^T \geq \frac{r+\delta}{2\alpha}$.

Finally, *Clark economies* are characterized by $L_C^T < \frac{r}{\alpha}$ and $L_C^T < \frac{r+\delta}{2\alpha}$. When the price rises above p^{++}, the resource is very valuable and calls for high effort so that the first best can be implemented (since both effort needs to be restricted less and the threat of exclusion lures larger), even though the manager in a Clark economy would have sufficient power to push effort down to the level L_C^T.

Figure 1 illustrates the different cases: At very low prices, all economies will exhibit open access, regardless of their characteristics. At high prices, "there is heterogeneity in the world's resource management with some countries at open access, others with limited management, and some with perfect property rights protection and full rent maximization" (Copeland and Taylor, 2009, Proposition 4).

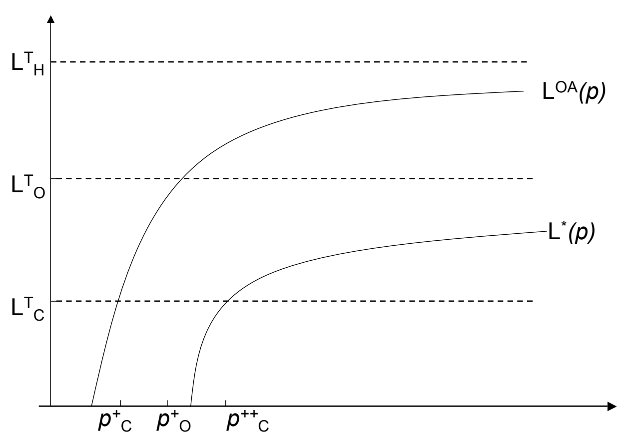

Figure 1: Endogenous property right regimes for Hardin, Ostrom, and Clark economies

1.2 Applications

Having these characterizations at hand, it is possible to prove the following proposition (Number 5 in Copeland and Taylor, 2009). Suppose an elimination of trade frictions leads to an price increase from p^{old} to p^{new}, then this will

(i) Reduce income in a Hardin economy

(ii) Increase income in Clark or Ostrom economy when $p^{old} > p^+$

(iii) Decrease income in Clark or Ostrom economies when $p^{old} < p^+$, but if $p^{new} > p^+$, then trade liberalization leads to the emergence of a management regime and increases income. For Clark economies, if $p^{new} > p^{++}$, management is fully efficient.

Further anecdotes from fisheries and forests.

2 The Resource Curse

"Ten years from now, twenty years from now, you will see: oil will bring us ruin... Oil is the Devil's excrement."

–Venezuelan politician Juan Pablo Perez Alfonzo, one of the founders of OPEC[2]

2.1 The "paradox of the plenty" and its explanations

Natural resources are not uniformly distributed over the earth's crust. Oil, diamonds, etc. are concentrated in only some handful countries. In spite of a very rich endowment, some countries have performed very poorly. For example,

> "Nigeria's per capita GDP in 2000 was 30% lower than in 1965, despite oil revenue receipts of roughly $ 350 billion (1995 $) over that period. During 1970-1990 Venezuela's terms of trade grew 13.7% per year due to its oil exports, but its output per capita fell by 1.4% per year. In the same country, public spending jumped so sharply during the 1979-1981 oil price spike that its government actually ran a current account deficit. Saudi Arabia's GDP per capita was lower in 1999 than it was before the oil price increases of the 1970s. According to Gylfason (2001, p. 848), OPEC as a whole experienced per capita GNP decreases of 1.3% per year during 1965-1998, while income increased at an average rate of 2.2% per year in all lower and middle-income countries." (Deacon, 2010, pp.1)

The idea that resource richness is not a blessing but a curse appears paradoxical and has spurred intensive research. At the same time, it is clear that some resource rich countries have grown rapidly (e.g. Botswana, Chile (after Pinochet), Malaysia and Norway). Hence, the study of the resource curse is related to the deeper economic question why some countries grow rich and others remain poor.

[2] Cited from `http://en.wikipedia.org/wiki/Resource_curse`

We will first outline the main mechanisms why resource abundance could lead to poor performance (slow growth, corrupted governments/institutions, and even civil war). Then we present some theories why resource rents have lead to poor growth in some countries but not in others.

The (neo-)classical explanation for the resource curse is the "Dutch Disease" (according to the malign experience of The Netherlands after discovering natural gas in the North Sea): The resource boom leads to an appreciation of the country's exchange rates, which makes its manufacturing goods less competitive. If the latter sector is the engine of growth but the former is not, then a crowding out of manufacturing industries will lead to slower growth.

A "crowding out" mechanism may also work on other types of investment. In particular, entrepreneurial talent may be siphoned into the resource sector or into other rent-seeking activities. This can lead to a lack of diversification. Bureaucracies may blow up and there could be underinvestment in general education as this may not be needed for resource extraction.

Other market-based explanations stress the role of factor price volatility. Resource prices fluctuate widely and make long-term planning difficult.

Yet another strand of the explanations focus on the corruption of governments/institutions. Since the government has a large income from resource rents, it does not need to tax its constituency, but in turn, it may be held less accountable. In fact, a large part of the resource rent may stay in the hands of a relatively small elite, taken out of the country or used to strengthen the position of the ruling regime.

This last aspect is related to the correlation of resource abundance and civil conflict: resource rents may fuel the oppression of an opposition, they may invite conflicts over their distribution, lead to separatist movements of resource-rich provinces and may be used to prolongue civil wars.

Let us now turn to the question why resource abundance appears to have an adverse effect in some countries but not in others. Some theories see political institutions as a causal factor that explains how a country responds to windfall gains from resource extraction. Other theories explain how resource rents could cause institutions to change. This obviously begs the question of the direction of causality. In the end, it is an empirical question, and the answer will depend on whether institutions are perceived as fast- or slow-changing entities, that is, how exactly the researcher defines "institutions".

First, "voracity" models describe the polar case of bad governance: Politically powerful groups can appropriate highly productive capital from a common pool. These groups can transfer capital to less productive but secure sectors, leading to reduced welfare. We will discuss one specific model of this type below.

Second, "rent-seeking" models start from assuming that there is a limited amount of talent (entrepreneurial skill) that can be either be devoted to modern increasing-returns firms or to rent-seeking activities in the resource sector. In equilibrium, the rate of return in both the productive and the non-productive sector are equalized, but the latter depends on the institutions of the country. When institutions are "grabber friendly" larger resource rents will shift talents away from the modern sector and reduces income. In fact, if resource rents are large enough, even an economy with an initially productive equilibrium may succumb to the rent-seeking equilibrium.

Third, models of rent-induced regime transitions work via the competition to stay in office. Imagine a situation where the party that has lost the elections can decide to acquiesce or to start a conflict. Which option will be preferable will depend on the pie that the ruler can divide. The larger the pie, the higher the incentives to start fighting over it instead of waiting for a new chance at the next election.

2.2 Hartwick's rule in a fractionalized society: A voracity model

Hartwick's rule prescribes to invest all rents from exhaustible resources in reproducible capital, which – in the the first-best of a homogenous society – allows to sustain the highest possible constant consumption path. However, if society is made up of many rival groups, non-cooperative extraction will be faster, leading to a lower level of constant consumption. The following model is based on van der Ploeg (2010):

Consider a country whose population is divided in N rival groups that all share access to the same pool of the resource. Let the stock of that resource at time 0 be $S(0) = S_0$. Aggregate extraction is then:

$$\dot{S} = -\sum_{i}^{N} R_i \tag{10}$$

Production Y requires man-made and natural capital, K and R, respectively. It is assumed to be Cobb-Douglas: $Y_i = f(K_i, R_i) = K_i^{\alpha} R_i^{\beta}$. Production can either be consumed or invested in man-made capital:

$$\dot{K}_i = Y_i - C_i \tag{11}$$

Assume further that all groups are Rawlsians, i.e. they adhere to the maxi-min criterium: The objective of each group is to choose that level of constant consumption that maximizes its utility (where ρ is the common pure rate of time preferences):

$$U_i = \int_0^{\infty} u(C_i) e^{-\rho t} dt \tag{12}$$

We conjecture that the extraction from each group is proportional to the remaining resource stock divided by the accumulated capital of that group.[3]

$$R_i = \sigma_i \frac{S}{K_i} \tag{13}$$

Consequently, the Hamiltonian associated with choosing C_i and R_i to maximize (12) subject to (10) and (11) and the conjecture (13) is:

$$\mathcal{H}_i = u(C_i) + \lambda_i \left(K_i^{\alpha} R_i^{\beta} - C_i \right) - \mu_i \left(R_i + \sum_{j \neq i} \sigma_j \frac{S}{K_j} \right). \tag{14}$$

The first-order conditions for optimality include:

$$\frac{\partial \mathcal{H}_i}{\partial C_i} = u'(C_i) - \lambda_i = 0, \tag{15}$$

$$\frac{\partial \mathcal{H}_i}{\partial R_i} = \lambda_i \beta \frac{Y_i}{R_i} - \mu_i = 0, \tag{16}$$

$$\rho \lambda_i - \dot{\lambda}_i = \frac{\partial \mathcal{H}_i}{\partial K_i} = \lambda_i \alpha \frac{Y_i}{K_i}, \tag{17}$$

$$\rho \mu_i - \dot{\mu}_i = \frac{\partial \mathcal{H}_i}{\partial S} = -\mu_i \left(\sum_{j \neq i} \sigma_j \frac{1}{K_j} \right). \tag{18}$$

Note that the marginal product of natural resources should equal the price of natural resources and define $p_i = \beta \frac{Y_i}{R_i} = \frac{\lambda_i}{\mu_i}$. Similarly, the marginal product of capital should equal the rate of return on capital and define $r_i = \alpha \frac{Y_i}{K_i}$. Finally, denote $K = \sum_i^N K_i$ and $\sigma = \sum_i^N \sigma_i$.

Differentiating (16) wrt to time yields $\dot{\lambda}_i p_i + \lambda_i \dot{p}_i = \dot{\mu}_i$. Insert this as well as the original equation (16) into (18). This gives:

$$\rho[\lambda_i p_i] - [\dot{\lambda}_i p_i + \lambda_i \dot{p}_i] = -[\lambda_i p_i](N-1)\frac{\sigma}{K}$$

Use (17) for $\dot{\lambda}_i$:

$$\rho \lambda_i p_i - [\rho \lambda_i - \lambda_i r_i] p_i - \lambda_i \dot{p}_i = -\lambda_i p_i (N-1) \frac{\sigma}{K},$$

[3] Methodologically, we propose equilibrium extraction takes the feedback form (13) and show that it indeed satisfies the necessary conditions for optimality.

which – upon canceling $\rho\lambda_i p_i$, dividing by $\lambda_i p_i$, and re-writing – yields:

$$\frac{\dot{p}_i}{p_i} = r_i + (N-1)\frac{\sigma}{K} \tag{19}$$

This is what van der Ploeg (2010, p.368) calls the "political variant of the Hotelling rule". In a homogenous society ($N = 1$) we have the conventional Hotelling rule, which says that the resource price should rise at the rate of interest. Fractionalization of society, however, drives a wedge in the Hotelling rule. Each group speeds up its extraction as it expects its rival to deplete this stock were it to postpone extraction.

We are looking for constant consumption paths[4], so that we propose a constant savings rate $\dot{K} = sY$. To find an expression for the aggregate savings rate $s = \frac{\dot{K}}{Y}$, denote the capital output ratio by $Z = \frac{K}{Y}$. Obtain

$$\dot{Z} = \frac{\dot{K}Y - \dot{Y}K}{Y^2} = \frac{K}{Y}\left[\frac{\dot{K}}{K} - \frac{\dot{Y}}{Y}\right]$$

Use the production function in differentiated form and expand with $(1-\beta)$

$$\dot{Z} = \frac{K}{Y}\left[\frac{\dot{K}}{K} - \alpha\frac{\dot{K}}{K} - \beta\frac{\dot{R}}{R}\right]$$

$$\dot{Z} = \frac{K}{Y}\left[\frac{\frac{\dot{K}}{K} - \alpha\frac{\dot{K}}{K} - \beta\frac{\dot{R}}{R} - \beta\frac{\dot{K}}{K} + \alpha\beta\frac{\dot{K}}{K} + \beta^2\frac{\dot{R}}{R}}{1-\beta}\right]$$

$$\dot{Z} = \frac{K}{Y}\left[\frac{(1-\alpha-\beta)\frac{\dot{K}}{K} + \beta\left(\frac{\dot{Y}}{Y} - \frac{\dot{R}}{R}\right)}{1-\beta}\right]$$

Then use the fact that $\dot{Y} = 0$ and thus $\dot{Z} = \frac{K}{Y}\left[\frac{\dot{K}}{K} - \frac{\dot{Y}}{Y}\right] = \frac{\dot{K}}{Y}$. The static efficiency condition $p = \beta Y/R$ implies $\frac{\dot{p}}{p} = \frac{\dot{Y}}{Y} - \frac{\dot{R}}{R}$. Now, use the modified Hotelling rule (19) to obtain:

$$\frac{\dot{K}}{Y} = \frac{K}{Y}\left[\frac{(1-\alpha-\beta)\frac{\dot{K}}{K} + \beta\frac{Y}{K}\left(\alpha + \frac{(N-1)\sigma}{Y}\right)}{1-\beta}\right]$$

[4] By the way, note that the Ramsey rule for consumption growth can be found by differentiating (15) wrt to time $\dot{\lambda} = u''(C)\dot{C}$ and inserting this and (15) into (17): $\rho u'(C) - u''(C)\dot{C} = u'(C)r$, yielding:

$$\frac{\dot{C}}{C} = \theta(r-\rho), \qquad \text{where} \quad \theta = -\frac{u'(C)}{Cu''(C)}$$

Hence, since $s = \frac{\dot{K}}{Y}$, the savings rate in a fractionalized society is:

$$s = \frac{(1-\alpha-\beta)s + \beta\left(\alpha + \frac{(N-1)\sigma}{Y}\right)}{1-\beta}$$
$$(1-\beta)s = (1-\beta)s - \alpha s + \alpha\beta + \frac{\beta\sigma}{Y}(N-1)$$
$$s = \beta + \frac{\beta\sigma}{\alpha Y}(N-1) > \beta \tag{20}$$

Note that in a homogenous society ($N = 1$), the savings rate is $s = \beta$, implying $\dot{K} = \beta Y = pR$ which is the Hartwick rule. Due to the rivalry of the groups, extraction is too fast, savings are excessive and consequently the constant consumption level is lower.

2.3 Empirical evidence: Is the paradox a “red herring”?

Brunnschweiler and Bulte (2008) point out much of the prior empirical research documenting the curse has relied on a peculiar proxy for resource abundance, namely the ratio of resource exports to GDP. They argue that this measure is more appropriately thought of as measure of resource dependence. The ratio of resource exports to GDP suffers from endogeneity as both the scale of the economy and the comparative advantage of non-resource sectors are largely a result of economic policies. They instrument resource dependence by trade openness and a presidential system dummy or measure of institutional quality, respectively. The latter variables turn out to be significant and negatively correlated with resource dependence, suggesting that countries with bad institutions depend on resource industries because these is a sector of last resort which does not depend on a sophisticated and efficient bureaucracy etc. They propose a new measure for “resource abundance”, namely subsoil assets as measured by the World Bank, and show that resource dependence loses its significance whereas resource abundance has a significant positive effect on country’s growth. They conclude that the resource curse does not exist.

However, van der Ploeg and Poelhekke (2010) point out that Brunnschweiler and Bultes measurement of resource abundance itself maybe endogenous itself. In particular, where reserve data are missing, “World Bank takes a pragmatic approach” and assumes the same remaining lifetime regardless of type, place, and date, so that “The value of subsoil assets for 2000 [...] is thus simply 18.3 times current natural resource rents” (van der Ploeg and Poelhekke, 2010, p.46). Correcting for this and other econometric issues, van der Ploeg and Poelhekke (2010) do not find a resource curse either, but subsoil assets cease to be significant. They do find that resource exports boost growth in stable countries, but makes volatile countries even more volatile. The latter channel may indirectly worsen growth prospects.

Hence, the overall question remains open. It has become clear that – in the words of Deacon (2010, p.2) – "the label "curse" cannot be applied without qualification. Still, the notion that having more of *any* natural resource could be disadvantageous in *any* circumstance is sufficiently puzzling to invite further study."

Reading list

Copeland, B. R. and Taylor, M. S. (2009). Trade, tragedy, and the commons. *American Economic Review*, 99(3):725–49.

van der Ploeg, F. (2010). Voracious transformation of a common natural resource into productive capital. *International Economic Review*, 51(2):365–381.

Additional references

Brunnschweiler, C. N. and Bulte, E. H. (2008). The resource curse revisited and revised: A tale of paradoxes and red herrings. *Journal of Environmental Economics and Management*, 55(3):248–264.

Bulte, E. and Barbier, E. (2005). Trade and renewable resources in a second best world: An overview. *Environmental and Resource Economics*, 30:423–463.

Deacon, R. (2010). The political economy of the natural resource curse: An interpretive survey. available at `www.econ.ucsb.edu/~deacon/Political%20Economy%20paper%20June2.pdf`.

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van der Ploeg, F. and Poelhekke, S. (2010). The pungent smell of "red herrings": Subsoil assets, rents, volatility and the resource curse. *Journal of Environmental Economics and Management*, 60(1):44 – 55.