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GENUINE SAVING AND THE VORACITY EFFECT

Frederick van der Ploeg*

Abstract

Many resource-rich countries have negative genuine saving rates, so deplete their exhaustible natural resource wealth faster than they build up wealth in other assets. This phenomenon is stronger in more fractionalized countries with poor legal systems. We explain this by a power struggle about the control of natural resources. Competing fractions in society thus have a *private* stock of financial assets and a *common* stock of natural resources. We solve a dynamic common-pool problem and obtain political economy variants of the Hotelling rule for resource depletion and the Hartwick saving rule necessary to sustain constant consumption in an economy with exhaustible natural resources. Resource depletion is faster than demanded by the Hotelling rule. As a result, the country has negative genuine saving rates and is running down its national wealth. The country saves more in financial assets than the current natural resource rents. Still, the erosion of natural wealth exceeds the accumulation of financial assets. Even though the power struggle boosts output, consumption is sub-optimally low. The highlighted political distortions are larger if the country is more fractionalized.

JEL code: E20, F32, O13, Q01, Q32

Keywords: Exhaustible natural resources, Hotelling resource rents, Hartwick rule, genuine saving, capital, sustainable consumption, rapacious rent seeking, common pool, voracity, fractionalization

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Countries rich in natural resources have poor growth performance even after controlling for the quality of institutions, openness, the investment rate and initial income per capita (e.g., Sachs and Warner, 1995). A rule of thumb based on the Hartwick rule is to save the rents from extracting and selling natural resources and invest them in physical capital, infrastructure or education.[1] However, in practice, many resource-rich countries save less than that. If they were to save more, they might grow at a faster rate. Hamilton and Hartwick (2005), Hamilton, Ruta and Tajibaeva (2005) and the World Bank (2006) present estimates of *genuine* saving. Genuine saving is defined as public and private saving at home and abroad, net of depreciation, *plus* current spending on education to capture changes in intangible human capital *minus* depletion of natural exhaustible and renewable resources *minus* damage of stock pollutants (CO_2 and particulate matter). Dasgupta and Mäler (2000) show that genuine saving thus defined corresponds to the increase in the wealth of the nation and that realization of the constant maxi-min level of consumption demands *zero* genuine saving.[2] [3] Any depletion of natural resources or damage done by stock pollutants must thus be compensated for by increases in non-human and/or human capital.

Figure 1 confirms that countries with a large percentage of mineral and energy rents of GNI typically have *negative* genuine saving rates.[4] Many countries become poorer each year despite have abundant natural resources. They squander their natural resources at the expense of future generations without investing sufficiently in other forms of intangible or productive wealth. This helps to explain why oil-rich Venezuela has negative economic growth while Botswana, Ghana and China with positive genuine saving rates enjoy substantial growth. Highly resource-dependent Nigeria and Angola have genuine saving rates of minus 30 percent, thus clearly impoverishing future generations. The oil/gas states of Azerbaijan, Kazakhstan, Uzbekistan, Turkmenistan and the Russian Federation also have negative genuine saving rates. Oil-rich states such as Nigeria or Venezuela, oil/gas-rich Trinidad and Tobago and copper-rich Zambia would have enjoyed an increase in productive capital by a factor four or five if the

[1] The Hartwick rule is first put forward by Hartwick (1977) for the closed economy. Dixit, Hammond and Hoel (1980) and Dasgupta and Mitra (1983) discuss it from the point of view of max-min egalitarianism.

[2] In fact, Dasgupta (2001) shows that wealth per capita is the correct measure of social welfare if the population growth rate is constant, per capita consumption is independent of population size, production has constant returns to scale, *and* current saving is the present value of future changes in consumption.

[3] The Hartwick rule is related to Hicksian real income. Asheim and Weitzman (2001) and Sefton and Weale (2006) show that the rule ensures no change in the present discounted value of current and future utility and requires use of the Divisia index of real consumption prices. Capital gains represent the capitalization of the future changes in factor prices and thus constitute a transfer from one factor to another. In the closed economy net gains are zero and should not be included in real income.

[4] The following resources are included: bauxite, copper, iron ore, lead, zinc, phosphates, silver, gold, oil, natural gas, brown coal, hard coal, tin, and nickel.

Hartwick rule would have been followed during the past three decades. All these countries (except Trinidad and Tobago) have suffered declines in per capita income from 1970 to 2000.

Of course, countries *should* save less than their natural resource rents and postpone extraction if they anticipate better times. For example, Asheim (1986, 1996) and Vincent, Panayotou and Hartwick (1997) show this socially optimal if the world price of natural resource is expected to rise in the future. Resource-rich countries should even run a current account deficit if natural resource rents fall short of the imputed interest on the value of natural resource reserves, which is more likely if the stock of reserves of natural resources is high. Hamilton and Bolt (2004) show, however, that the adjustments to allow for future changes in resource prices are small if historical price trends are extrapolated. Another reason why it is socially optimal to have negative genuine saving rates is if countries expect the cost of resource extraction to fall in the future.[5] Furthermore, countries should save less if they expect government spending to fall in the future. Without knowing what the expectations are for future developments of the world price of natural resources, the cost of resource extraction and government spending, it is difficult to accuse resource-rich countries of saving too little.

However, if there are political factors underlying the observed negative genuine saving rates, this is not the case. To see whether this may be important, we examine whether the number of competing groups in society might affect genuine saving rates negatively. Figures 2 and 3 give a weak indication that countries with a share of mineral rents greater than 5 percent have more negative genuine saving rates if they have a high degree of ethnic fractionalization and suffer from internal conflict. Corruption is also associated with negative genuine saving rates in resource-rich countries. It may thus be worthwhile to develop a political economy explanation of why resource-rich countries deplete their natural resources relatively faster than they build up other assets.

Our objective is thus to shed light from a *positive* perspective on why countries save less than natural resource rents. Rival groups are introduced and each one of them tries to grab a share of natural resource revenues before others can do so. The problem is that property rights for natural resources do not exist or are badly defined. We apply the ideas developed by Lane and Tornell (1996) and Tornell and Lane (1999) on how a common-pool problem may give rise to the voracity effect to the analysis of the optimal depletion of exhaustible resources and saving in

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[5] The US historical experience suggests that under the right circumstances anticipated falls in the cost of extraction and thus the downward effect on the nation's saving may be substantial. The US supremacy as mineral producer was driven by big falls in exploration costs from the mid-nineteenth to mid-twentieth century, collective learning, leading education in mining/engineering/metallurgy, increasing returns, private initiative and an accommodating legal environment; see Habbakuk (1962) and David and Wright (1997).

financial assets. We show that the power struggle makes competing groups more impatient and thus the country depletes natural resources faster than suggested by the rule first derived by Hotelling (1931). As a result, the country experiences negative genuine saving rates which depresses the sustainable level of consumption and harms social welfare (the voracity effect). We also show that the Hartwick rule must be modified for these political distortions. The only way for each group to sustain a constant level of private consumption is for the economy as a whole to save more than natural resource rents. Still, genuine saving will be negative as the price of natural resources is initially too low and rises too fast. Consequently, erosion of natural wealth exceeds accumulation of financial wealth. We also establish that the political distortions in the Hotelling and Hartwick rules are bigger if the country is more fractionalized. We derive our results for a closed economy with natural resources as a factor of production. We show that the non-cooperative saving rate is greater than the production share of natural resources, but less than the production share of capital. The interest rate and the output-capital ratio gradually fall to zero. Genuine saving is negative, so that the country is impoverished all the time and can only sustain a sub-optimally low level of consumption. Hence, a fractionalized society experiences negative genuine saving and sustains a smaller level of consumption than a homogenous society.

I. Political distortions in the Hotelling and Hartwick rules

N rival groups struggle for power over the control of natural resources. Each group *i* grabs a share σ_i of natural resource reserves *S*. Depletion of the stock of natural reserves is thus given by:

$$(1) \qquad \dot{S} = -\sum_{j=1}^{N} R_j, \quad S(0) = S_0 \quad \text{or} \quad \int_0^\infty \sum_{j=1}^{N} R_j(s)\,\mathrm{d}s = S_0,$$

where R_j denotes the depletion rate of group *j* in society. The natural resource stock is a *common* stock, since it is depleted by all groups in society. This captures the idea that property rights on natural resources do not exist or are badly defined.

Each group *i* also accumulates private assets K_i. Since we abstract from adjustment costs, taxes, etc., the relative price of financial assets is unity and the value of private assets exactly equals the capital stock. The capital stock of each group can be viewed as physical capital or human capital. Each group *i* employs capital, natural resources R_i and labor L_i to produce output Y_i. The production function for each group Y_i = F(K_i, L_i, R_i) satisfies the Inada conditions and displays constant returns to scale. We assume that natural resources are *necessary* for production, so F(K_i, L_i, R_i) = 0. We also assume that natural resources are *inessential* for production to avoid that feasible consumption vanishes when natural resources run out. If there are sufficient substitution possibilities between resources and capital or labor, it is possible to generate positive levels of output by switching from resource-intensive to capital-intensive modes of production. With a CES production function, natural resources are neither necessary nor essential if the elasticity of substitution between factors of production exceeds unity. If the elasticity of substitution is less than unity, capital accumulation cannot compensate for the unavoidable decline in the use of natural resources and output and consumption must decline to zero. The economy is then doomed, so that natural resources are essential for production. We therefore assume that each group has a Cobb-Douglas production with a unit elasticity of factor substitution and a share of capital in value added greater than that of natural resources, i.e., $Y_i = K_i^{\alpha} R_i^{\beta} L_i^{1-\alpha-\beta}, \alpha > \beta > 0, \alpha + \beta < 1$. Natural resources are thus necessary, but not essential for production.[6] We assume that there is no depreciation of capital. We assume that total labor supply in the country is one and that each group is the same. If consumption by group i is denoted by C_i, the evolution of private wealth of group i is given by:

$$(2) \qquad \dot{K}_i = Y_i - C_i, \quad \text{where} \quad Y_i = K_i^{\alpha} R_i^{\beta} L_i^{1-\alpha-\beta} \text{ and } L_i = 1/N,$$

where labor supply is exogenous and equal to $1/N$. We abstract from extraction costs for natural resources. Suppose that the depletion of the common resource by each group is conjectured to be proportional to the remaining stock of resources divided by the accumulated wealth of the group:

$$(3) \qquad R_j = \sigma_j S / K_j, \quad j = 1,..,N,$$

where σ_j will be referred to as the *depletion coefficient*. It follows that in this closed economy each group i maximizes its utility

$$(4) \qquad U_i = \int_0^{\infty} \mathrm{u}(C_i)\exp(-\rho t)\mathrm{dt}, \quad \mathrm{u}' > 0, \mathrm{u}'' \leq 0,$$

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[6] If $\alpha < \beta$, capital does not add enough to production to compensate for the declining use of natural resources and sustain a positive level of private consumption. Resources are then essential for production.

subject to the evolution of the common stock (1), the evolution of the private stock (2) and (3) with the conjectures about the depletion coefficients of the other groups in society, σ_j , $j \neq i$, where ρ indicates the pure rate of time preference employed by each group.

A. *Optimality conditions for the feedback Nash equilibrium outcome*

We thus derive for this differential game a feedback Nash equilibrium solution with consistent conjectures based on the class of feedback policy rules (3). The Hamiltonian for group i is:

$$(5) \qquad H_i \equiv \mathrm{u}(C_i) + \lambda_i \left(K_i^{\alpha} \left(\frac{\sigma_i S}{K_i} \right)^{\beta} \left(\frac{1}{N} \right)^{1-\alpha-\beta} - C_i \right) - \mu_i \left(\sum_{j=1}^{N} \frac{\sigma_j S}{K_j} \right),$$

where λ_i and μ_i denote the marginal utility for group i of an extra unit of private capital and the common stock of natural resources, respectively. Application of Pontryagin's maximum principle yields the following first-order conditions for group i:

$$(6) \qquad \frac{\partial H_i}{\partial C_i} = \mathrm{u}'(C_i) - \lambda_i = 0, \quad \frac{\partial H_i}{\partial \sigma_i} = \beta \frac{Y_i}{R_i} \frac{S}{K_i} \lambda_i - \mu_i \frac{S}{K_i} = 0, \quad \rho \lambda_i - \dot{\lambda}_i = \frac{\partial H_i}{\partial K_i} = \alpha \frac{Y_i}{K_i} \lambda_i \equiv r_i \lambda_i$$
$$\text{and } \rho \mu_i - \dot{\mu}_i = \frac{\partial H_i}{\partial S} = \frac{\sigma_i}{K_i} \beta \frac{Y_i}{R_i} \lambda_i - \left(\sum_{j=1}^{N} \frac{\sigma_j}{K_j} \right) \mu_i .$$

Equation (6) implies that the marginal product of natural resources should equal the price of natural resources, $p_i \equiv \lambda_i / \mu_i$, and that the price of natural resources should rise at the rate of interest r_i plus an extra term proportional to the sum of the depletion rates of all groups. Furthermore, the marginal product of capital should equal the rate of return on capital for each group. Since in symmetric equilibrium the interest rates and natural resource prices are the same for each group, we can drop group subscripts and write these efficiency conditions as:

$$(7) \qquad \frac{\dot{p}}{p} = r + (N-1)\frac{\sigma}{K} \quad \text{where } \ p = \beta \frac{Y_j}{R_j}, r = \alpha \frac{Y_j}{K_j}, j = 1, \ldots, N, K \equiv \sum_{j=1}^{N} K_j \ \text{ and } \sigma \equiv \sum_{j=1}^{N} \sigma_j .$$

Equation (7) is the political variant of the Hotelling rule. If there is no fractionalization of society, $N = 1$ and (7) reduces to the familiar Hotelling rule which states that the expected rate of increase in natural resources should exactly equal the market rate of interest. This follows from the arbitrage condition that on the margin one should be indifferent between, on the one hand, keeping natural resources under the ground and receiving a capital gain $\dot{p}/p$, and, on the other hand, digging the resources up, selling them and receiving a rate of return *r*. Rival groups in society drive a wedge in the Hotelling rule. Effectively, each group downplays the capital gain on natural resources as it expects other groups to deplete the common stock of natural resources if it postpones depletion. As a result, the political Hotelling rule implies a bigger rate of increase in the price of natural resources than is socially optimal. This distortion is smaller if the groups have accumulated a lot of non-resource wealth relative to the stock of resource wealth.

Equation (6) also implies the Keynes-Ramsey rule for growth in private consumption:

$$(8) \qquad \frac{\dot{C}_i}{C_i} = \theta_i \left(r_i - \rho \right),$$

where $\theta_i \equiv -\mathrm{u}'(C_i)/C_i\,\mathrm{u}''(C_i) \geq 0$. Following the literature on the Hartwick rule, we are interested in max-min egalitarian outcomes with zero elasticities of intertemporal substitution (i.e., $\theta_i = 0$). We are thus looking for dynamic general equilibrium paths with constant levels of private consumption, $C_i(\mathrm{t}) = \mathrm{C}/N > 0$, $\forall \mathrm{t} \geq 0$ with $\mathrm{C} > 0$ a constant.

B. *Sustaining constant levels of private consumption*

Consider a feasible program with $K_i(\mathrm{t}) = \phi\,\mathrm{t} + \mathrm{K_0/N} > 0$, $\forall \mathrm{t} \geq 0$ where $\mathrm{K_0/N}$ is the initial private stock of assets of each group. Since investment is constant in such a program, the level of output $Y_i(\mathrm{t}) = \phi + \mathrm{C}/N$ is constant as well. Aggregating and making use of the product market equilibrium condition (2) yields aggregate use of natural resources in production:

$$(9) \qquad R(\mathrm{t}) \equiv \sum_{j=1}^{N} R_j(\mathrm{t}) = \left(N\phi + C \right)^{1/\beta} \left(N\phi \mathrm{t} + K_0 \right)^{-\alpha/\beta}.$$

Substituting (9) into the depletion of natural reserves equation (1), integrating and solving gives:

$$(10) \qquad C = \left(\frac{\alpha - \beta}{\beta} \right)^{\beta} \left(N\phi S_0 \right)^{\beta} K_0^{\alpha-\beta} - N\phi \;\text{ and }\; R(\mathrm{t}) = \left(\frac{\alpha - \beta}{\beta} \right) N\phi S_0 K_0^{(\alpha-\beta)/\beta} \left(N\phi \mathrm{t} + K_0 \right)^{-\alpha/\beta}.$$

The level of aggregate private consumption that can be sustained is obviously larger if the initial stock of private assets and common stock of natural reserves are higher. For a meaningful solution to exist, one must have $\alpha > \beta$. If this is not the case, output cannot be sustained at a constant level with a finite stock of natural resources even if all of output is saved. Consequently, if $\alpha < \beta$, private consumption eventually vanishes.[7] We also have from substituting R(t) from (10) into the depletion equation (1) and integrating, the trajectory for the stock of natural resources:

(11) $$S(\mathrm{t}) = \left(\frac{K_0}{K_0 + N\phi t} \right)^{(\alpha-\beta)/\beta} S_0 \to 0 \quad \text{as} \quad \mathrm{t} \to \infty.$$

The stock of natural reserves is thus asymptotically fully depleted.

The solution trajectories for capital, natural resources, output, the interest rate and the price of natural resources are pinned down once we know the hypothesized value of ϕ. To find this value, we must make use of the static and dynamic efficiency conditions summarized in (7). This yields the following relationship between the aggregate depletion coefficient σ and the constant ϕ:

(12) $$\alpha N\phi = \alpha\beta \left(\frac{\alpha-\beta}{\beta} \right)^{\beta} \left(N\phi S_0 \right)^{\beta} K_0^{\alpha-\beta} + \beta \left(\frac{N-1}{N} \right) (N\phi \mathrm{t} + K_0)\sigma(\mathrm{t}).$$

Combining (3), (10) and (11) yields another relationship between σ and ϕ and thus the depletion rate of the common stock of natural resources:

(13) $$\sigma(\mathrm{t}) = \left(\frac{\alpha-\beta}{\beta} \right) N\phi \equiv \sigma \quad \Rightarrow$$
$$R(\mathrm{t}) = \left(\frac{\alpha-\beta}{\beta} \right) N\phi \frac{S(\mathrm{t})}{K(\mathrm{t})} = \left(\frac{\alpha-\beta}{\beta} \right) N\phi \left(\frac{K_0^{\alpha-\beta}}{N\phi \mathrm{t} + K_0} \right)^{1/\beta} S_0 \to 0 \quad \text{as} \quad \mathrm{t} \to \infty.$$

Hence, the aggregate depletion coefficient is constant in non-cooperative equilibrium while the depletion rate itself declines with time and vanishes asymptotically.

[7] Natural resources are also essential if physical capital depreciates in a radioactive manner, but not if depreciation is linear or proportional to output.

C. *Zero genuine saving in a homogenous society*

Consider a society without any rival fractions. In that case, $N = 1$ so that (12) and (13) yield:

$$(14) \qquad \phi = \left[\beta \left(\frac{\alpha - \beta}{\beta} \right)^{\beta} S_0^{\beta} K_0^{\alpha - \beta} \right]^{1/(1-\beta)} \quad \text{and} \quad \sigma = \left(\frac{\alpha - \beta}{\beta} \right) \left[\beta \left(\frac{\alpha - \beta}{\beta} \right)^{\beta} S_0^{\beta} K_0^{\alpha - \beta} \right]^{1/(1-\beta)} .$$

Making use of (10) and (14), we establish that the saving rate of a homogenous society equals:

$$(15) \qquad s(\mathrm{t}) \equiv \frac{\dot{K}(\mathrm{t})}{Y(\mathrm{t})} = \beta.$$

This is the celebrated Hartwick rule, which states that the country should save all its natural resource rents and thus that the saving rate should exactly equal the share of natural resources in value added β. The aggregate genuine saving rate of the economy is, however, given by:

$$(16) \qquad s_G(\mathrm{t}) \equiv \frac{\dot{K}(\mathrm{t}) + p(\mathrm{t})\dot{S}(\mathrm{t})}{Y(\mathrm{t})} = \frac{\beta Y(\mathrm{t}) - p(\mathrm{t})R(\mathrm{t})}{Y(\mathrm{t})} = 0.$$

The Hartwick rule requires that the depletion of natural wealth is exactly compensated by accumulation of physical capital, hence genuine saving must be zero. We will show that this result does not hold in a fractionalized society. In a homogenous society it is possible to sustain constant levels of private consumption, output and investment. Investment is positive and compensates exactly for the loss in natural wealth. The value of natural resources extracted at each point of time pR does not change over time, so that the depletion level of resources falls at exactly the same rate as the price of resources appreciates. This rate is, of course, the market rate of interest in a homogenous society, which declines over time and vanishes asymptotically. This is also the case for the fraction appropriated from the stock of natural resources (i.e., $R/S = \sigma/K$).

D. *Negative genuine saving in a fractionalized society*

With many rival fractions ($N > 1$), we substitute (13) in (12) and solve for aggregate investment:

$$(14') \qquad N\phi = \left(\frac{\alpha\beta \left(\frac{\alpha-\beta}{\beta} \right)^{\beta} K_0^{\alpha-\beta} S_0^{\ \beta} N}{\alpha + \beta(N-1)} \right)^{\frac{1}{1-\beta}}.$$

We thus find that the saving ratio can be written as:

$$(15') \qquad s(\mathrm{t}) \equiv \frac{\dot{K}(\mathrm{t})}{Y(\mathrm{t})} = \frac{N\phi}{N\phi + C} = \left(\frac{\alpha N}{\alpha + \beta(N-1)} \right) \beta > \beta \ \text{ if } N > 1 \ \text{ and } \ s(\mathrm{t}) \to \alpha \ \text{if} \ N \to \infty.$$

A fractionalized society saves more than the natural resource rents, so that the saving rate exceeds β. As the number of rival fractions increases, the saving rate rises gradually from β towards α. The constant level of output is readily seen to be higher in more fractionalized societies. The aggregate genuine saving rate of a country with N rival fractions is given by:

$$(16') \qquad s_G(\mathrm{t}) \equiv \frac{\dot{K}(\mathrm{t}) + Np(\mathrm{t})\dot{S}(\mathrm{t})}{Y(\mathrm{t})} = s(\mathrm{t}) - N\beta = -\frac{\beta^2 N(N-1)}{\alpha + \beta(N-1)} < 0 \ \text{ if } N > 1.$$

A fractionalized society thus has a negative aggregate genuine saving rate. Furthermore, as the number of rival fractions increases, the genuine saving rate becomes even more negative. Rapacious appropriation of natural resources leads to too rapid depletion rates and too rapid appreciation of natural resource prices compared with the socially optimal depletion rates and natural resource prices implied by the Hotelling rule. It follows that the erosion of the value of natural resource wealth is too rapid. It even exceeds the accumulation of financial assets, so that genuine saving is negative. The political determinants of this dynamic common-pool problem follow from the lack of effective property rights for natural resources. They help to explain why many fractionalized resource-rich countries experience negative genuine saving rates, especially if the quality of their legal system is poor. As a result, each group consumes less than they would do in the absence of the voracity effect. To see this, note from (14′) that $\partial(N\phi)/\partial N > 0$ and from (10) that $\partial C/\partial(N\phi) = -(\alpha-\beta)(N-1)/\alpha N < 0$ if $N > 1$. It follows that $\partial C/\partial N < 0$ if $N > 1$. Effectively, fractionalization boosts saving and investment more than output. Hence, the more fractionalized a society, the less each group ends up consuming. Rapacious rent seeking hurts consumption by the members of each group and harms social welfare.

Proposition: *In the absence of well-defined property rights for natural resources and rival groups in society, the rate of resource depletion and appreciation of the price of natural resources are faster than suggested by the Hotelling rule. Consequently, natural resource wealth diminishes too quickly. Still, the nation saves more than its natural resource rents and thus the saving rate exceeds the national income share of natural resources. The accumulation of financial assets is insufficient to make up for the decline in natural resource wealth, hence genuine saving is negative and the country becomes poorer all the time. Output increases by less than saving and investment, so that consumption is sub-optimally low. These political distortions become bigger as the country becomes more fractionalized.*

E. *Comment*

A strong government could correct for the political distortions by levying a tax on natural resource use by each group and rebating the revenues in a lump-sum fashion. This would correct for the intertemporal distortion in the Hotelling rule and return the economy back to the Hartwick rule. Such a policy slows down the rate of natural resource depletion and returns private consumption back to its socially optimal level. Of course, a resource-rich country with strife about natural resources is unlikely to have a strong government.

In the closed economy model of capital accumulation and natural resource depletion capital grows ad infinitum while the rate of interest and the depletion rate decline to zero. If positive total factor productivity growth is introduced, there may be a steady state with a positive interest rate and a positive depletion rate (e.g., Dasgupta and Heal, 1974). It can be shown that the qualitative insights of the dynamic common-pool problem and the political variants of the Hotelling and Hartwick rules are not affected.

Like most discussions of the Hartwick rule, we have adopted a max-min egalitarian perspective and used a zero elasticity of intertemporal substitution. If groups adopt a positive elasticity of intertemporal substitution ($\theta_i > 0$), levels of private consumption will not be constant. If consumption is initially held for some time below its max-min level, capital is accumulated at a sufficiently fast pace to ensure that later generations enjoy ever-increasing levels of consumption. While resource use declines to zero, unlimited growth in consumption and output is feasible. The Keynes-Ramsey rule (8) implies that, as long as the rate of time preference is strictly positive, the capital stock must ultimately go to zero as well to ensure that growth in private consumption is non-negative. It is thus optimal to let consumption, output and capital vanish in the long run even though it is feasible to not have such a doomsday scenario. Future generations are thus doomed, but from a utilitarian perspective that does not matter as the benefit to early generations exceeds the loss to later generations. Rival groups in a fractionalized society bring forward consumption even more, which is also happens if groups are impatient and find intertemporal substitution easy (large ρ or θ). Obviously, it is hard on ethical grounds to defend the socially optimal outcome for a homogenous society. This is why the max-min egalitarian outcome seems preferable.

II. Conclusion

The *negative* genuine saving rates of many resource-rich countries damage their growth prospects and harm welfare. Undoubtedly, they perform better if they invest their exhaustible resource rents as suggested by the Hartwick rule. If competing groups fight to get a big share of natural resource revenues, they deplete natural resource reserves faster than implied by the Hotelling rule. As a result, resource prices rise to fast. This follows from the impatience induced by such power struggles and common-pool problems. We have shown that this gives a political explanation of negative genuine saving rates. To sustain constant private consumption, the country needs to save more than the natural resource rents. The voracity effect implies that the people accumulate less financial assets and have less to consume in a society with rival groups fighting about natural resource revenues. We have shown that these political distortions in the Hotelling and Hartwick rules are especially large in countries with a large degree of fractionalization and poor legal systems. People really are worse off.

More work is needed on how the Hotelling rule and the Hartwick rule should be modified for practical policy formulation. We have shown that natural resource revenues may be siphoned off by the political elite and their cronies and thus not reach the people. Less natural resource rents will thus be saved. Furthermore, natural resource bonanzas may induce exuberant public spending based on the incorrect assumption that windfall natural resource revenues are permanent. This leads to unsustainable spending levels with painful adjustments when resource revenues run out. It is important to study how advice on optimal rates of resource depletion, government spending, saving and investment survives when politicians seek office and grab resource rents for themselves or to pay off political opponents and get away with it due to poor institutions, bad legal systems and poor checks and balances in the political system. Rapacious rent seeking implies that many resource-rich, fractionalized countries with poor legal systems squander their natural resource rents and suffer disastrous economic and social outcomes.

Finally, many poor resource-rich economies have to cope with high population growth rates. Such countries need *positive* rather than *zero* genuine saving rates to maintain constant consumption per head, since genuine saving may be positive while wealth per capita declines (e.g., World Bank 2006, Table 5.2). Such countries are on a treadmill and need to save more than their exhaustible resource rents, but rarely manage that. For them the political distortions arising from the voracity effect are particularly painful.

References

Asheim, G.B. (1986). Hartwick's rule in open economies, *Canadian Journal of Economics*, 19, 395-402.

Asheim, G.B. (1996). Capital gains and net national product in open economies, *Journal of Public Economics*, 59, 419-434.

Asheim, G.B. and M.L. Weitzman (2001). Does NNP growth indicate welfare improvement, *Economics Letters*, 73, 2, 233-239.

Dasgupta, P. (2001). *Human Well-Being and the Natural Environment*, Oxford University Press, Oxford.

Dasgupta, P. and G.M. Heal (1974). The optimal depletion of exhaustible resources, *Review of Economic Studies*, Symposium, 3-28.

Dasgupta, P. and K.-G. Mäler (2000). Net national product, wealth, and social well-being, *Environment and Development Economics*, 5, 69-93.

Dasgupta, P.S. and T. Mitra (1983). Intergenerational equity and efficient allocation of exhaustible resources, *International Economic Review*, 24, 133-153.

David, P.A. and G. Wright (1997). Increasing returns and the genesis of American resource abundance, *Industrial and Corporate Change*, 6, 203-245.

Dixit, A.P., P. Hammond and M. Hoel (1980). On Hartwick's rule for regular maximin path of capital accumulation, *Review of Economic Studies*, 47, 551-556.

Habbakuk, H.J. (1962). *American and British Technology in the Nineteenth Century*, Cambridge University Press, Cambridge, U.K.

Hamilton, K. and K. Bolt (2004). Resource price trends and development prospects, *Portuguese Economic Review*, 3, 85-97.

Hamilton, K. and J.M. Hartwick (2005). Investing exhaustible resource rents and the path of consumption, *Canadian Journal of Economics*, 38, 2, 615-621.

Hamilton, K., G. Ruta and L. Tajibaeva (2005). Capital accumulation and resource depletion: A Hartwick rule counterfactual, Policy Research Working Paper 3480, World Bank, Washington, D.C.

Hartwick, J.M. (1977). Intergenerational equity and the investing of rents from exhaustible resources, *American Economic Review*, 67, 5, 972-974.

Hotelling, H. (1931). The economics of exhaustible resources, *Journal of Political Economy*, 39, 137-175.

Lane, P.R. and A. Tornell (1996). Power, growth and the voracity effect, *Journal of Economic Growth*, 1, 2, 213-241.

Sachs, J.D. and A.M. Warner (1995 and revised 1997). Natural resource abundance and economic growth, in G. Meier and J. Rauch (eds.), *Leading Issues in Economic Development*, Oxford University Press, Oxford.

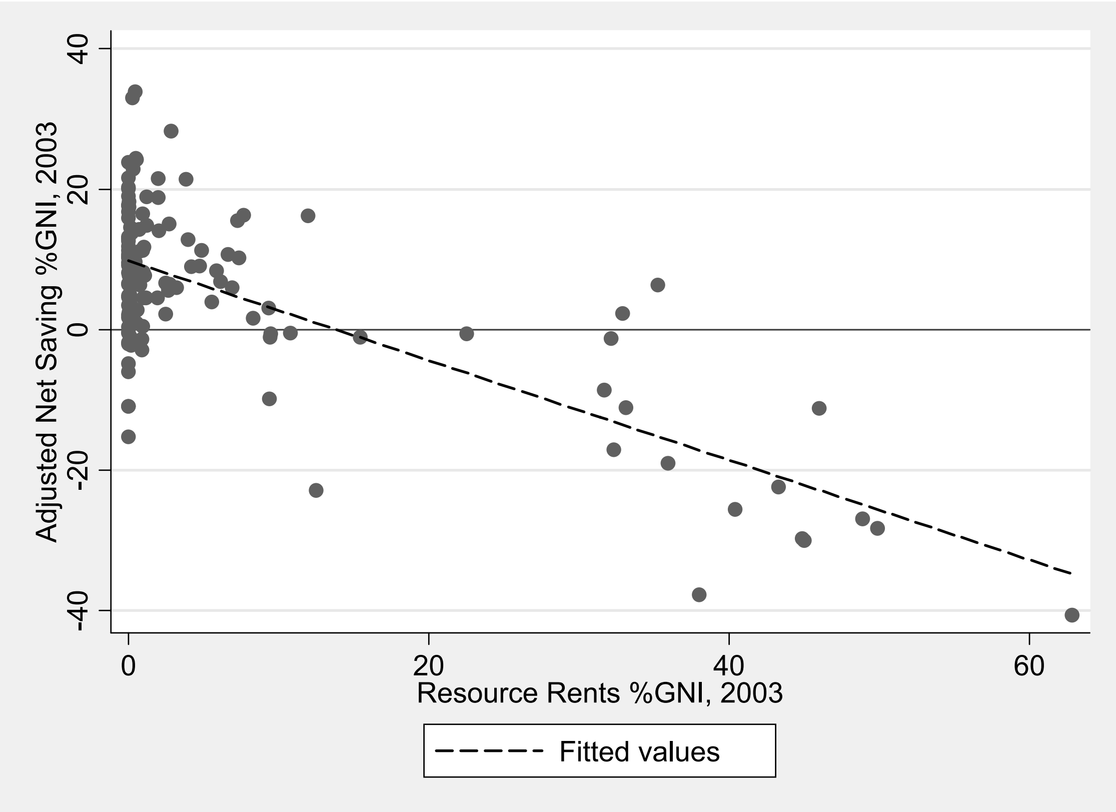
Sefton, J.A. and M.R. Weale (2006). The concept of income in a general equilibrium, *Review of Economic Studies*, 73, 219-249.

Tornell, A. and P.R. Lane (1999). The voracity effect, *American Economic Review*, 89, 1, 22-46.

Vincent, J.R., Th. Panayotou and J.M. Hartwick (1997). Resource depletion and sustainability in small open economies, *Journal of Environmental Economics and Management*, 33, 274-286.

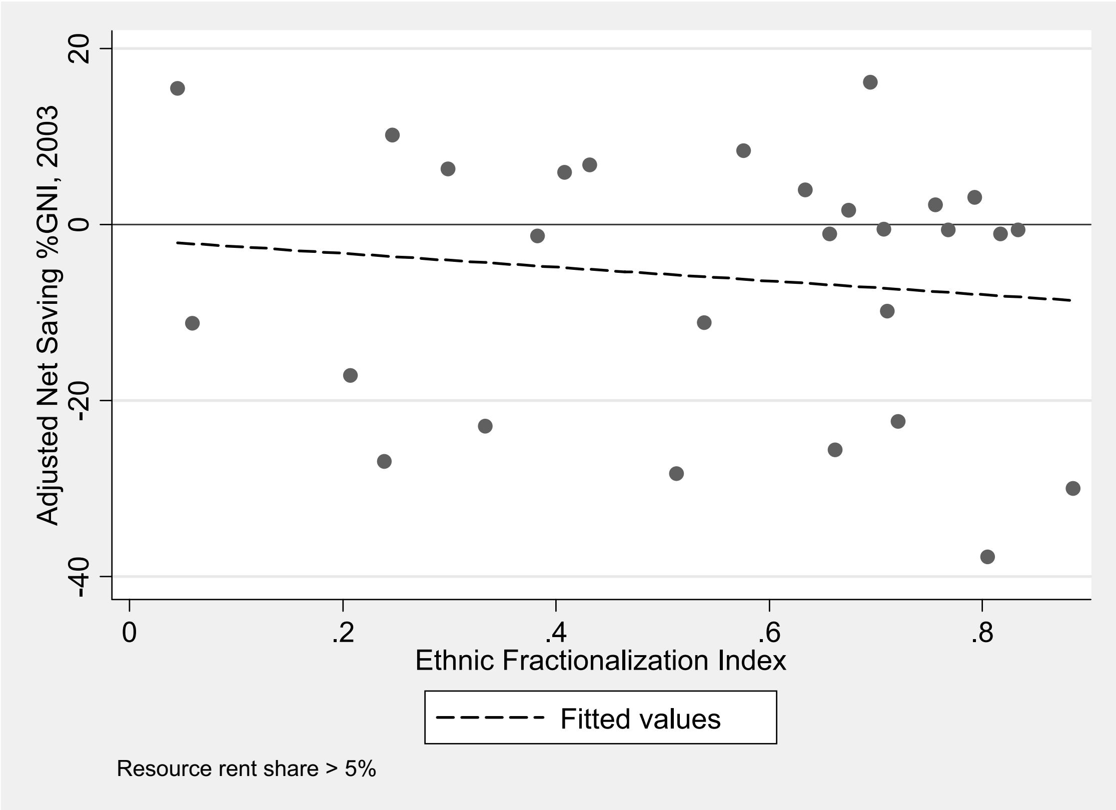
World Bank (2006). *Where is the Wealth of Nations? Measuring Capital for the 21st Century*, International Bank for Reconstruction and Development/World Bank, Washington, D.C.

Figure 1: Genuine saving and exhaustible resource share



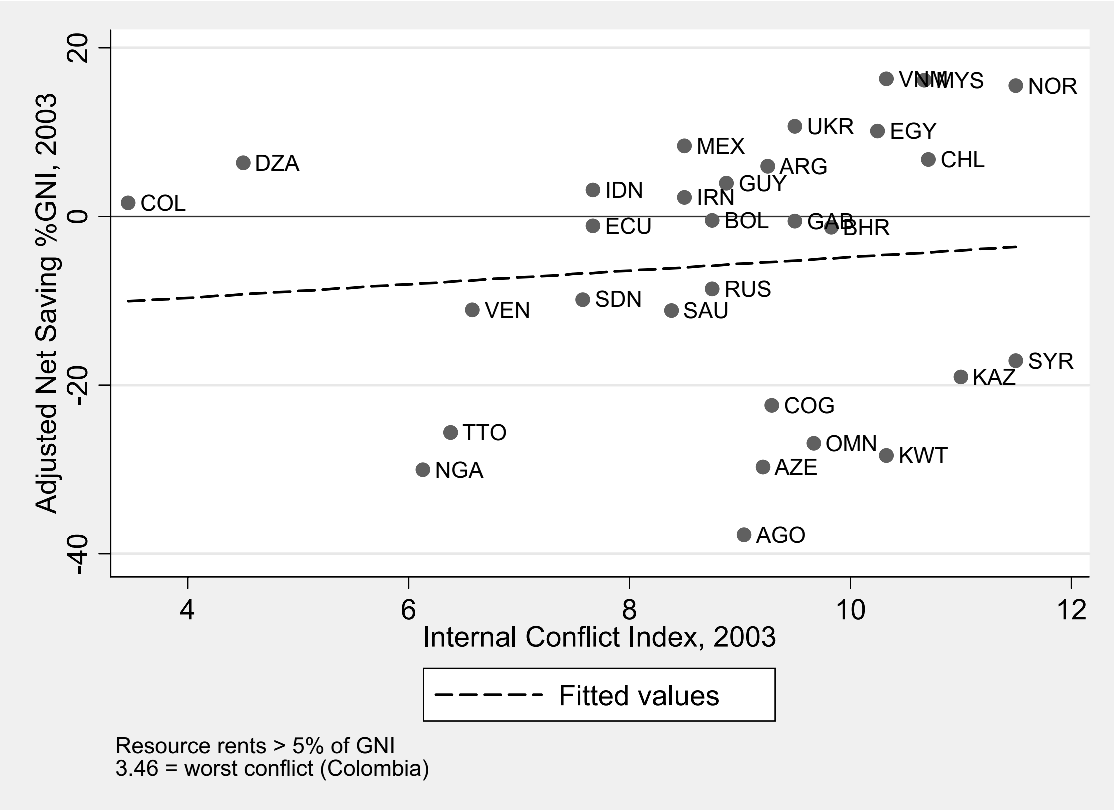
Source: World Bank (2006)

Figure 2: Genuine saving and ethnic fractionalization for resource-rich countries



Source: International Country Risk Guide and World Bank (2006)

Figure 3: Genuine saving and internal conflict for resource-rich countries



Source: International Country Risk Guide and World Bank (2006)