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Why Do Many Resource-Rich Countries Have Negative Genuine Saving?

Anticipation of better times for rapacious rent seeking

Revised June 2009

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WHY DO MANY RESOURCE-RICH COUNTRIES HAVE NEGATIVE GENUINE SAVING?

Anticipation of better times or rapacious rent seeking

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Abstract

We investigate the Hartwick rule for saving of a nation necessary to sustain a constant level of private consumption for a small open economy with an exhaustible stock of natural resources. The amount by which a country saves and invests less than the marginal resource rents equals the expected capital gains on reserves of natural resources plus the expected increase in interest income on net foreign assets plus the expected fall in the cost of resource extraction due to expected improvements in extraction technology. Effectively, depletion is then postponed until better times. This suggests that it is not necessarily sub-optimal for resource-rich countries to have negative genuine saving. However, in countries with different groups with imperfectly defined property rights on natural resources, political distortions induce faster resource depletion than suggested by the Hotelling rule. Fractionalised societies with imperfect property rights build up more foreign assets than their marginal resource rents, but in the long run accumulate less foreign assets than homogenous societies. Hence, such societies end up with lower sustainable consumption and are worse off, especially if seepage is strong, the number of rival groups is large and the country does not enjoy much monopoly power on the resource market. Genuine saving is zero in such societies. However, World Bank genuine saving figures based on market rather than accounting prices will be negative, albeit less so in more fractionalised societies with less secure property rights.

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I. INTRODUCTION

Many economies endowed with an abundance of natural resources varying from oil, gas and diamond to copper and tin have poor growth performance even after controlling for the quality of institutions, openness, the investment rate and the initial level of income per capita (e.g., Sachs and Warner, 1997; Mehlum, Moene and Torvik, 2005; Arezki and van der Ploeg, 2006; Poelhekke and van der Ploeg, 2009). Despite advice from the World Bank and other supranational organisations and NGO's to save at least the rents from extracting and selling natural resources[1], these resource-rich economies typically save less than that. If they were to save more, they might grow at a faster rate. To get a better understanding of sustainable development, it is useful to look at some numbers for *genuine* saving (e.g., Hamilton and Hartwick, 2005). Genuine savings is defined as public and private saving at home and abroad, net of depreciation, *plus* current spending of 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). Since genuine saving thus defined corresponds to the increase in the wealth of the nation (Dasgupta and Mäler, 2000), the constant maxi-min level of consumption demands *zero* genuine saving.[2] [3] It thus requires that any depletion of natural resources or damage done by stock pollutants must be compensated for by increases in non-human and/or human capital. Although this rule of zero genuine saving is often seen as a rule of thumb or motivated by max-min egalitarianism, it can be the outcome of maximising utilitarian utility in an open economy without resource exports if the rate of time preference equals the world rate of interest (e.g., Okumura and Cai, 2007).

[1] This policy recommendation is based on the Hartwick rule, which is derived from maxi-min egalitarian considerations. The rule says that the marginal Hotelling rents on natural resources should be fully saved and reinvested in physical capital, infrastructure or education (e.g., Hartwick, 1977; Dixit, Hammond and Hoel, 1980; Dasgupta and Mitra, 1983). With a Cobb-Douglas production function, the saving rate then corresponds exactly to the constant production share of natural resources. Hartwick (1995) discusses the open economy version of the Hartwick rule.

[2] In fact, 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 (Dasgupta, 2001a).

[3] The Hartwick rule is related to the Hicksian definition of real income, i.e., the "maximum amount a man can spend and still be as well off at the end of the week as at the beginning". The general equilibrium features of this 'green' definition of real income, which ensures no change in the present discounted value of current and future utility and requires ue of the Divisia index of real consumption prices, are now well understood (Asheim and Weitzman, 2001; Sefton and Weale, 2006). The return on the increasingly scarce resource rises at the expense of the increasingly abundant production factors. Capital gains represent the capitalisation of the future changes in factor prices. They constitute a transfer from one factor to another, so in a closed economy net gains are zero and should not be included in the definition of real income.

Illustrative estimates of genuine saving are calculated in World Bank (2006) and presented in Figure 1 (also Hamilton, Ruta and Tajibaeva, 2005). They paint a rather gloomy picture. Countries with a large percentage of mineral and energy rents of GNI typically have *negative* genuine saving rates. This means that many countries become poorer each year despite have abundant natural resources. They effectively squander their natural resources at the expense of future generations without investing in other forms of intangible or productive wealth. Figure 2 suggests that this may explain why Venezuela shows negative economic growth rates while countries such as Botswana, Ghana and China with positive genuine saving rates enjoy substantial growth rates. Highly resource-dependent Nigeria and Angola have genuine saving rates of minus 30 percent and future generations are clearly being impoverished. The oil/gas states of Azerbaijan, Kazahkstan, Uzbekistan, Turkmenistan and the Russian Federation also have negative genuine saving rates. They seem to consume or even waste their resource rents.

Figure 3 reports the counter-factual experiment of calculating by how much productive capital would increase by 2000 if countries would have invested all their natural resource rents from crude oil, natural gas, coal, bauxite, copper, gold, iron, lead, nickel, phosphate, silver and zinc in productive capital from 1970 onwards. Unfortunately, the calculations only provide an upper bound as they abstract from marginal extraction costs due to data problems. High resource dependence is defined as at least a 5 percent share of resource rents in GDP. The World Bank suggests that especially the resource-rich countries that now have negative genuine saving such as Nigeria or Venezuela would have experienced substantial increases in productive capital by a factor of five or four if the Hartwick rule would have been followed in the past. This is also true for oil- and gas-rich Trinidad and Tobago and copper-rich Zambia. All the countries in the top right quadrant (except Trinidad and Tobago) have experienced declines in per capita income from 1970 to 2000. Obviously, if the Hartwick rule would have been followed during the last few decades, these economies would have been much less dependent on oil and other resources.

The two crucial questions are why is it that so many resource-rich countries save so little and whether it really is that sub-optimal for them to do so. Of course, there may be political economy reasons for negative genuine saving to do with poor institutions, corruption and badly functioning capital markets. However, even if there are no such obvious government and market failures, countries *should* save less than their marginal Hotelling rents on natural resources and postpone extraction if they expect the world price of natural resource prices to rise in the future (Asheim, 1986, 1996; Vincent, Panayotou and Hartwick, 1997). This is the case if the world price of natural resources follows the Hotelling rule and increases at a rate equal to the world interest rate. Countries with abundant natural resources should then run a current account deficit if the marginal Hotelling rents on natural resources fall short of the imputed interest on the value of natural resource reserves. This is more likely if the stock of reserves of natural resources is high. In practice, the adjustments to allow for future changes in resource prices are apparently quite small if historical price trends are extrapolated (Hamilton and Bolt, 2004).

Our main objective of this paper is to investigate why many resource-rich countries save less than their marginal Hotelling rents on natural resource reserves. We extend the above *normative* line of reasoning to anticipated changes in other variables. This is closely related to earlier results on how to deal with time-varying exogenous variables in green accounting by Vellinga and Withagen (1996). They show that the optimal saving rule includes the integral of all the future values of the exogenously time-varying variables such as the world interest rate and world market prices. We argue that countries should not only save less if they expect world prices of resources to increase in the future, but also if they expect interest income on net foreign assets to rise and the cost of resource extraction to fall in the future. Furthermore, countries should save less if they expect government spending to fall in the future. Without knowing what the expectations are for the future developments of the world price of natural resources, the world interest rate, the cost of resource extraction and government spending, it is difficult to accuse resource-rich countries of saving too little. To assess whether resource-abundant nations save too little from a purely normative point of view, thus requires careful empirical analysis.

More fundamentally, this paper sheds light from a *positive* perspective on why countries might extract their natural resources too fast and build up too few foreign assets and thus have to make do with lower levels of sustainable consumption. We do this by allowing for political economy features. Competing groups are introduced which try to get their share of natural resource revenues. Each group has access to its own stock of exhaustible natural resources. However, due to seepage of oil or gas from the field of one of group to the fields of all the other groups, these natural resource pools are interconnected.[4] Hence, there is a common-pool problem and the non-cooperative and the cooperative outcomes will differ. More interestingly, seepage can also be interpreted as lack of effective property rights on each group's stock of natural resources.[5] Effectively, the power struggle makes competing groups more impatient and thus the

[4] It would have been possible to examine the implications of one common pool of natural resources, which corresponds to a sequence of interconnected pools with an infinite speed of seepage (as was done for a closed economy in van der Ploeg, 2008). In the small open economy context of this paper, an infinite speed of seepage implies that the non-cooperative outcome leads to instant depletion of the natural resource and therefore it is infeasible to sustain a constant level of consumption. With finite speeds of seepage and interconnected pools, we show that it is feasible to sustain a constant level of consumption.

[5] This also underlies the voracity effect (e.g., Lane and Tornell, 1996; Tornell and Lane, 1999). A key difference is that this paper does not assume that the natural resource stocks yield a higher rate of return

country depletes resources faster than suggested by the Hotelling rule. Somewhat surprisingly, such fractionalised economies will be shown to have zero genuine saving as the accumulation of foreign assets and depletion of natural resources occur too fast but are in line. Still, reported genuine saving figures that use market rather than accounting prices will be negative. We show that the Hartwick rule must be modified for these political distortions. The only way to sustain a constant level of private consumption is to save in the short run more on the current account than the current marginal Hotelling resource rents. But as depletion occurs too fast, natural resource revenues and marginal resource rents decline faster than is socially optimal. As a result, in the long run fractionalised societies with poor legal systems and a lot of seepage between the exploration fields of the various groups end up with less foreign assets than homogenous societies and a lower level of sustainable consumption. Societies with badly defined property rights and rapacious rent seeking induced by seepage and many competing rival factions really are worse off, especially if they do not enjoy much monopoly power on the market for natural resources.

Section II calculates heuristically the Hartwick rule for a small open one-sector economy with perfect capital mobility and some monopoly power in the sale of its exhaustible resources on the world market. The impact of productivity improvements in extraction, changes in the world interest rate and the world price of resources on the Hartwick rule are analysed. Section III provides a normative underpinning of the analysis of section II and shows that anticipated improvements in extraction technology implies that it is optimal to have negative genuine saving rates. Section IV discusses how the optimal saving rule and resource depletion rates are modified in the presence of political common-pool problems. We do this in a context where there is seepage between the natural resource fields of competing factions in society or property rights on natural resources are imperfectly defined. It derives political variants of the Hotelling rule and the Hartwick rule. We show that the presence of rival groups and a lack of effective property rights imply that the nation depletes its exhaustible resources too fast and ends up with lower levels of foreign assets (i.e., a smaller sovereign wealth fund) and lower sustainable consumption and lower social welfare in the long run. We also derive the appropriate accounting prices necessary to calculate genuine saving and show that in highly fractionalised societies with insecure property rights genuine saving is nevertheless zero. Reported measures of genuine saving that use market rather than accounting prices to value the cost of resource depletion will then be negative. Section

than the private stocks of productive capital. If this was the case, it may well be that the transformation of natural resources into productive capital induces a lower growth rate. In this paper, however, we focus on the concept of sustainable consumption and attempt to understand why reported genuine saving measures tend to be negative for resource-rich countries.

V concludes and discusses the implications of our results for the appropriate calculation of genuine saving figures and for economic policy.

II. NEGATIVE GENUINE SAVING IN ANTICIPATION OF BETTER TIMES

Consider a small open economy with constant population $L = 1$ and a stock of exhaustible natural resources S. Let us for sake of argument refer to natural resources as oil. The cost of extracting q units of oil is $A\Psi(q)$ with $\Psi'>0$ and $\Psi''\geq 0$, where a fall in A indicates an improvement in extraction technology. The cost of oil extraction increases with the depletion level. Consumption and capital goods are traded on the world markets at a given price (normalised at unity). Production takes place according to a neoclassical production function $\mathrm{F}(K,L) \equiv \mathrm{f}(K)$ with $\mathrm{f}'>0$ and $\mathrm{f}''<0$, where K stands for the stock of capital. Since natural resources are not a factor input into domestic production, this model is sometimes referred to as the 'Kuwait model'.[6] To focus on the plight of resource exporters, we abstract from the use of natural resources in production. In fact, if capital is not used in domestic production, we have a rentier economy which uses its natural resource wealth to buy foreign assets. The economy faces world demand for its oil:

$$(1) \qquad q = \mathrm{q}(p/p^*) \quad \text{with} \quad \eta \equiv -p\mathrm{q}'(p)/q > 1,$$

where p denotes the price of its oil on the world market, p^* stands for the world price of oil sold by its competitors and η indicates the constant elasticity of world demand for oil. A low value of η indicates a high degree of monopoly power in the sale of oil on world markets. The rate of change in the depletion rate of oil thus falls if the rate of change in the price charged for oil exceeds that charged in the world market:

$$(1') \qquad \dot{q}/q = -\eta(\pi - \pi^*), \quad \text{where} \quad \pi \equiv \dot{p}/p \text{ and } \pi^* \equiv \dot{p}^*/p^*.$$

[6] Our model should be contrasted with the interesting model of Okumura and Cai (2007), who assume that natural resources are not sold on the world market, capital and resources are essential and complementary factors of production and the rate of time preference equals the world interest rate. They then show that the open economy version of the Hartwick rule demands that the sum of investment in physical capital plus saving in foreign bonds should equal natural resource rents. Also, both the use of resources and the use of capital decline over time but the rate of decline of resource use is faster than that of capital. As a result, it is possible to maintain a constant level of private consumption. Effectively, capital use, resource use and domestic production vanish completely in the long run while private consumption is wholly sustained on the interest income of accumulated foreign assets.

Agents in this economy have perfect access to the world capital market and take the world interest rate *r* as given. If *F* denotes the stock of net foreign assets and *G* government spending on commodities, the saving of the nation is given by:

(2) $$\dot{F} = r(F - K) + \left[pq - A\Psi(q) \right] + \mathrm{f}(K) - C - G,$$

where *C* indicates private consumption. Alternatively, the current account equals interest income on net foreign assets *plus* net revenue from oil exports *minus* net imports of commodities and capital goods by households, firms and the government:

(2′) $$\dot{F} - \dot{K} = r(F - K) + \left[pq - A\Psi(q) \right] - \left[C + G + \dot{K} - \mathrm{f}(K) \right].$$

The government finances its spending with non-distorting taxes, which makes sense with inelastic labour supply. The initial stock of oil S_0 defines the maximum amount of oil that can be depleted:

(3) $$\dot{S} = -q, \quad S(0) = S_0 \quad \text{or} \quad \int_0^\infty q(\mathrm{t})\mathrm{dt} = S_0.$$

There are two efficiency conditions, which would also follow from maximising profits from resource extraction subject to (3) and the world demand for resources:

(4) $$\mathrm{f}'(K) = r \quad \text{and} \quad \frac{\mathrm{d}\left[p\left(1 - \eta^{-1}\right) - A\Psi'(q) \right] / \mathrm{dt}}{p\left(1 - \eta^{-1}\right) - A\Psi'(q)} = r.$$

The first condition is standard and says that the marginal productivity of capital is set to the world interest rate. Profit-maximising firms would ensure this. The second efficiency condition is the Hotelling rule for optimal oil extraction. It requires the economy on the margin to be indifferent between, on the one hand, extracting oil, investing the proceeds and getting a return equal to the world interest rate *r*, and, on the other hand, keeping the oil under the ground and enjoying the capital gains on oil reserves net of marginal extraction costs.[7] The marginal Hotelling resource rents must thus increase at a rate equal to the world interest rate. The Hotelling rule implies that anticipated increases in the world oil price or anticipated future improvements in oil extraction technology (π, $\alpha > 0$) as well as a low world interest rate induce oil depletion to be postponed:

$$\frac{\dot{q}}{q} = \left[(1+\mu)\pi + \mu\alpha - r\right]/\,\varepsilon\mu, \quad \text{where } \alpha \equiv -\left(\frac{\dot{A}}{A}\right) \geq 0,$$

(5)

$$\mu \equiv \frac{A\Psi'(q)}{p\left(1-\dfrac{1}{\eta}\right) - A\Psi'(q)} > 0 \text{ and } \varepsilon \equiv \frac{q\Psi''(q)}{\Psi'(q)} > 0.$$

Using (1′) and (5), we obtain an alternative version of the Hotelling rule:

(6)

$$\pi = \frac{r - \mu\alpha + \mu\varepsilon\eta\pi^*}{1+\mu(1+\varepsilon\eta)} \text{ and } \frac{\dot{q}}{q} = -\eta\left(\frac{r - \mu\alpha - (1+\mu)\pi^*}{1+\mu(1+\varepsilon\eta)}\right).$$

If the resource exporter has no monopoly power on the world market ($\eta \to \infty$), its oil prices must follow the world prices ($\pi = \pi^*$). If world prices follow the Hotelling rule, we have that the rate of increase in the depletion rate is given by $\dot{q}/q = (r+\alpha)/\varepsilon$. The stock of reserves is then exhausted in finite time. Generally, the economy has some monopoly power on the oil market. With zero marginal cost of oil extraction, $\mu = 0$ and the price of oil increases at a rate equal to the world interest rate ($\pi = r$) and the rate of change in the depletion rate falls over time if the rate of change in the world price of oil exceeds the world interest rate. In general this is not the case and $\mu > 0$. Consider first the case that $\pi^* = 0$. If there are then no technological improvements in oil extraction ($\alpha = 0$), the rate of increase in the price of oil falls short of the world interest rate, especially if world demand for oil is elastic and marginal cost of oil extraction rises rapidly. In that case, the country depletes its reserves less rapidly. With exogenous improvements in oil extraction technology ($\alpha > 0$), the rate of increase in the price of oil and the rate of change in oil depletion are reduced even further. Effectively, it pays to delay depletion of reserves to reap the

[7] The cost of extraction may also increase as oil reserves S are depleted. In that case, the Hotelling rule becomes $\mathrm{d}\left(p\left(1-\eta^{-1}\right) - A\partial\Psi/\partial q\right)/\mathrm{d}t = r\left(p\left(1-\eta^{-1}\right) - A\partial\Psi/\partial q\right) + A\partial\Psi/\partial S$, so the expected gains corrected for changes in the marginal cost of extraction fall short of the world interest rate. The rate of depletion is somewhat slower, since the increasing costs of extraction as reserves fall are internalised.

benefits of technical progress. Now consider the case $\pi^* > 0$. This pushes up the rate of increase in the price of oil charged by the country and thus brings resource depletion forward.

Equation (6) defines the rate of change in resource depletion. To calculate the level of depletion, we substitute (6) into (3) and calculate the initial rate of resource depletion to exhaust fully the stock of reserves. To keep matters simple, we assume $r - \pi^* > \mu(\pi^* + \alpha)$ so that $\pi > \pi^*$ and reserves are not exhausted in finite time. If the world rate of interest and the world rate of increase in the price of oil are constant and there are no costs of extraction, we obtain the following expression for the initial rate of depletion:

(7) $$q(0) = \eta(\pi - \pi^*)\mathrm{S}_0 = \eta(r - \pi^*)\mathrm{S}_0.$$

The initial rate of depletion is low and reserves are exhausted relatively slowly if the world interest rate is low and the world rate of increase in the world price is high. In general, this is also the case if the rate of technical improvements in exploration technology is high.

Following Solow (1974), Hartwick (1977), Dixit, Hammond and Hoel (1980), Asheim (1986) and many others, we are interested in finding the maxi-min egalitarian outcome.[8] [9] This corresponds to the path of the economy that sustains a constant level of private consumption. This path is only optimal for economies with a constant population. The novel features of our analysis are that we allow for anticipated changes in the world interest rate, cost of oil extraction and government spending as well as changes in the world price of oil.

Proposition 1: The maxi-min level of constant private consumption can be sustained in a small open economy with one sector if the nation saves the following amount:

[8] For closed economies maxi-min optimality of the Hartwick rule is only guaranteed with constant population growth and no technical progress. Non-decreasing per-capita private consumption is infeasible under exponential population growth if resources are essential inputs in production and there is no technical progress (Dasgupta and Heal, 1974; Solow, 1974; Stiglitz, 1974), but feasible with quasi-arithmetic population growth (Mitra, 1983; Asheim et. al., 2007). A dynamic version of average utilitarianism can allow for the measurement of welfare and genuine saving with changing population (Dasgupta, 2001a; Arrow, Dasgupta and Mäler, 2003).

[9] With no population growth or technical progress, the Hartwick rule also results in a maxi-min optimum in economies with many consumption goods, heterogeneous capital goods and endogenous labour supplies provided there is free disposal and stock reversal (Dixit, Hammond and Hoel, 1980). An interesting question is whether a maxi-min optimum implies adherence to the Hartwick rule (Withagen and Asheim, 1998; Mitra, 2002).

(8)
$$\dot{F}(\mathrm{t}) = \left[p(\mathrm{t})\left(1 - \frac{1}{\eta}\right) - A(\mathrm{t})\Psi'(q(\mathrm{t})) \right] q(\mathrm{t}) + G^P(\mathrm{t}) - G(\mathrm{t})$$
$$- \int_{\mathrm{t}}^{\infty} \exp\left(-\int_{\mathrm{t}}^{\mathrm{s}} r(\mathrm{v})\mathrm{dv}\right)\left[\alpha(\mathrm{s})A(\mathrm{s})\Psi(q(\mathrm{s})) + \pi^*(\mathrm{s})p(\mathrm{s})q(\mathrm{s}) + \dot{r}(\mathrm{s})\left(F(\mathrm{s}) - K(\mathrm{s})\right)\right]\mathrm{ds},$$

where $G^P(\mathrm{t}) \equiv \int_{\mathrm{t}}^{\infty}\left[r(\mathrm{s})\exp\left(-\int_{\mathrm{t}}^{\mathrm{s}} r(\mathrm{v})\mathrm{dv}\right) G(\mathrm{s})\mathrm{ds} \right]$ denotes the permanent level of public spending.

Proof: Postulate that the nation's saving corresponding to a sustainable constant level of consumption is given by $\dot{F} = [p(1 - \frac{1}{\eta}) - A\Psi'(q)]q + X$, where X is an unknown term to be determined. Differentiating this expression with respect to time and setting it equal to the result of differentiating the expression for national saving with respect to time, yields:

$$\ddot{F} = [p(1 - \frac{1}{\eta}) - A\Psi'(q)]\dot{q} + q\,\mathrm{d}[p(1 - \frac{1}{\eta}) - (A\Psi'(q))]/\mathrm{dt} + \dot{X} =$$
$$r\dot{F} + \dot{r}(F - K) + \left[p(1 - \frac{1}{\eta}) - A\Psi'(q) \right]\dot{q} + \pi^* pq - \dot{A}\Psi(q) - \dot{C} - \dot{G}.$$

Simplifying and making use of the Hotelling rule, we obtain for a constant level of *C*:

$$\dot{X} = rX + \pi^* pq + \dot{r}(F - K) - \dot{A}\Psi(q) - \dot{G}.$$

Forward integration of this differential equation from time t to ∞ and substitution of the resulting solution into the postulated equation for the nation's saving yields:

$$\dot{F}(\mathrm{t}) = \left[p(\mathrm{t})(1 - \frac{1}{\eta}) - A(\mathrm{t})\Psi'(q(\mathrm{t})) \right] q(\mathrm{t}) +$$
$$\int_{\mathrm{t}}^{\infty} \exp\left(-\int_{\mathrm{t}}^{\mathrm{s}} r(\mathrm{v})\mathrm{dv}\right)\left[\dot{A}(\mathrm{s})\Psi(q(\mathrm{s})) + \dot{G}(\mathrm{s}) - \pi^*(\mathrm{s})p(\mathrm{s})q(\mathrm{s}) - \dot{r}(\mathrm{s})\left(F(\mathrm{s}) - K(\mathrm{s})\right)\right]\mathrm{ds}.$$

Integration by parts of the term involving the change in government spending and imposition of the transversality condition gives the level of saving that sustains the constant maxi-min level of private consumption. □

This saving rule is a modification of the Hartwick rule for an open economy (Vincent, Panayotou and Hartwick, 1997) and consists of six parts. First, the nation saves the marginal Hotelling oil rents valued at the world oil price minus marginal extraction costs. Effectively, depletion of oil reserves must be offset by increases in foreign assets. Second, the nation saves less and delays resource depletion if it expects the world price of oil to increase in the future. Third, the nation saves less if it is a net creditor (i.e., *F*>*K*) and expects the world interest rate to increase in the future. It is then optimal to save less now and postpone oil extraction to profit from the higher future interest rate. Of course, if the nation is a net debtor, it is optimal to speed up resource depletion and borrow less. Fourth, the nation also saves less if the economy expects future improvements in oil extraction technology. Fifth, the country saves less and may even borrow if there is a temporary increase in government spending (i.e., $G - G^P > 0$). This may happen during recession or war. Also, if greying of the population is anticipated, the cost of pensions and health care are expected to increase and thus it is optimal for a country to save more. This familiar use of the current account to smooth consumption is, of course, well known (e.g., Sachs, 1981). A final insight that can be obtained from this version of the Hartwick rule is there should be a zero correlation between saving of the nation and investment. Alternatively, if we have the current account $\left(\dot{F} - \dot{K}\right)$ rather than net saving on the left-hand side, we see that the current account should be fully used to finance investment.[10]

In sum, the saving of the nation equals the marginal Hotelling oil rents *minus* the discounted value of the sum of expected capital gains on oil reserves, expected increases in interest income on net foreign assets and expected reductions in oil extraction costs (due to improvements in extraction technology) *plus* the amount by which the permanent level of government spending exceeds the current value of government spending. A special case arises if the price it fetches for its oil follows the Hotelling rule and increases at the world interest rate r and the rate of change in the depletion rate is given by $\dot{q}/q = -\eta(r - \pi^*)$ (e.g., if there are no extraction costs). If the world interest rate is constant, the maxi-min saving rule becomes:

$$(8') \qquad \dot{F} = p\left(1 - \frac{1}{\eta}\right)q + (G^P - G) - \pi^* pS.$$

Hence, in that case a constant level of private consumption is sustained if the nation saves the marginal Hotelling oil rents *minus* the imputed erosion of the value of oil reserves due to trend inflation in world oil prices. A country with substantial oil reserves thus saves less than a country with almost no oil reserves, because it makes sense to sell more of its reserves in the future when the world price of oil will be higher. This is the opposite of much advice that oil-rich countries receive from oil importers and supranational organisations like the World Bank and the IMF.

It is easy to solve the model recursively. The Hotelling rule gives the rate of change of oil extraction (5), which upon substitution into (3) allows one to calculate the initial rate of resource

[10] As is well known from Feldstein and Horioka (1980) and the literature thereafter, saving of the nation and investment are empirically closely correlated. This phenomenon is known as the Feldstein-Horioka puzzle.

depletion $q(0)$ given the path of the world price of oil and the state of exploration technology, the world interest rate and the initial stock of oil reserves. Clearly, the whole trajectory of oil depletion $\{q(t), t \geq 0\}$ shifts up after the discovery that the stock of oil reserves is higher than previously thought. The capital stock is tied down by the world interest rate from the first part of (4). One can then solve for the accumulation of net foreign assets F given the temporary level of public consumption $G - G^P$ from (6). Finally, one can solve for private consumption C from (2).

III. NORMATIVE UNDERPINNING OF THE HARTWICK RULE

Before we move to the political determinants of negative genuine saving rates, we provide a welfare-based, micro-founded underpinning of the result that it is optimal to have negative genuine saving rates when better times are anticipated. To keep matters simple, we abstract from inflation in the world price of oil and government spending. We also set the pure rate of time preference to the world interest rate. Let preferences of the representative household be given by:

(9) $$U = \int_0^\infty \mathrm{u}(C)\exp(-\rho t)\mathrm{d}t, \quad \mathrm{u}' > 0, \mathrm{u}'' \leq 0,$$

where ρ denotes the pure rate of time preference. We assume a constant world rate of interest. The government maximises subject to the constraints (2), (3) and the inverse demand function for oil $p = \mathrm{p}(q)$, $\mathrm{p}' < 0$. The present-value Hamiltonian function is defined by:

(10) $$H \equiv \mathrm{u}(C) + \lambda\left[r(F - K) + \mathrm{p}(q)q - A\Psi(q) + \mathrm{f}(K) - C\right] - \mu q,$$

where λ and μ indicate the marginal utility of an extra unit of foreign bonds and oil reserves, respectively. Application of Pontryagin's maximum principle yields the necessary conditions:

(11) $$\mathrm{u}'(C) = \lambda, \quad \dot{\lambda} = 0, \quad \mathrm{f}'(K) = r, \quad \dot{\mu} = \rho\mu \quad \text{and} \quad \left[p\left(1 - \frac{1}{\eta}\right) - A\Psi'(q)\right]\lambda = \mu.$$

It follows from (11) that it is optimal to have a constant level of private consumption $\dot{C} = 0$. In addition, it is optimal to have the marginal product of capital equal to the world rate of interest and to have the Hotelling rule as stated in (4). Using the same arguments as before, we find that the optimal level of saving in foreign bonds plus investment in physical capital is less than the marginal Hotelling natural resource rents if extraction costs are expected to fall:

(12)
$$\begin{aligned}\dot{F}(\mathrm{t}) &= \left(1-\frac{1}{\eta}\right)p(\mathrm{t})q(\mathrm{t}) - A\Psi'(q) + \int_t^\infty \exp(-r(\mathrm{s}-\mathrm{t}))\dot{A}(\mathrm{s})\Psi(q(\mathrm{t}))\mathrm{ds} \\ &\leq \left(1-\frac{1}{\eta}\right)p(\mathrm{t})q(\mathrm{t}) - A\Psi'(q) \text{ if } \dot{A}(\mathrm{s}) \leq 0 \text{ for s} \geq \text{t.}\end{aligned}$$

More interesting, genuine saving in terms of commodity units rather than utility units is given by:

(13)
$$GS = \dot{F} + p_G\dot{S} = \int_t^\infty \exp(-r(\mathrm{s}-\mathrm{t}))\dot{A}(\mathrm{s})\Psi(q(\mathrm{t}))\mathrm{ds} \leq 0 \text{ if } \dot{A}(\mathrm{s}) \leq 0 \text{ for s} \geq \text{t,}$$

where $p_G \equiv \frac{\mu}{\lambda} = \left(1-\frac{1}{\eta}\right)p - A\Psi'(q) < p$ denotes the accounting price which needs to be used for calculating genuine saving. We have thus established that there are good normative reasons to have negative genuine saving when better times are expected. In other words, if a country anticipates future improvements in extraction technology, it will be socially optimal to have a negative genuine saving rate.

Finally, we note that it is important not to use the market price of natural resources p to evaluate genuine saving, but marginal revenue minus marginal extraction costs (i.e., marginal rents). As the World Bank measures of genuine saving rates seem to use market prices rather than properly defined accounting prices, they may be an under-estimate of the correct measure of genuine saving rates. Genuine saving rates would thus appear more negative than they should. We return to the bias in available estimate of genuine saving rates at the end of section IV.

IV. GENUINE SAVING AND RAPACIOUS RENT SEEKING

We now leave our normative setting and introduce some political elements in order to see whether this might explain negative genuine saving rates. We thus suppose that there is a power struggle for the control over revenues from the exhaustible stocks of natural resources. Assume that there are N competing groups in society and that each of them has access to their own field of exhaustible natural resources. These gas or oil fields are adjacent to each other. If stocks are higher in one field than in others, oil or gas gradually seeps to the other fields. Pumping up gas or oil would also lead to a lower stock of natural resources. It follows that we can describe the dynamics of the stock of natural resources of each group by the following differential equations:

$$\dot{S}_i = -q_i + \sum_{j \neq i} \xi (S_j - S_i), \quad S_i(0) = S_{i0}, \tag{14}$$

where S_i denotes the stock owned by group i and q_i denotes the pumping of oil or gas at any moment of time by group i. The parameter $\xi \geq 0$ denotes the speed by which oil or gas seeps from one field to the other fields, but can also be interpreted as the degree of imperfection of property rights on natural resources. Perfect property rights (and no seepage as might be the case of minerals like silver, gold or diamonds) would correspond to $\xi = 0$. If however, seepage is important or property rights are imperfect, we have $\xi > 0$ and each rival faction is tempted to deplete its stock of oil or gas before it seeps to other fields or is grabbed by others. We solve a dynamic common-pool problem with the aid of differential game theory. For simplicity, we abstract from oil extraction costs. We highlight and contrast the *uncontested private* stock of foreign assets (bonds and capital) held by each competing group, F_i , i = 1,…,N, with the *contested private* stock of oil or gas reserves, S_i , i = 1,...,N. Private oil or gas reserves are contested due to seepage or imperfectly defined property rights. We assume a Cobb-Douglas production function for each group in society, so that $\mathrm{f}(K_i) = K_i^{\alpha} \left(1/N\right)^{1-\alpha}, i = 1,..,N,$ where $0 < \alpha < 1$ denotes the constant share of capital in value added, K_i stands for the amount of capital used by group i and the term (1/N) corresponds to the amount of labour available per group in society. Aggregate production of all the groups is thus given by f(K), where $K \equiv \sum_{i=1}^{N} K_i$ indicates the aggregate capital stock.

Rival group i is ultimately interested in consuming as much private consumption C_i as possible and thus solves the following intertemporal maximisation problem:

$$\underset{C_i, q_i}{\mathrm{Max}} \quad \int_0^{\infty} \exp(-\rho \mathrm{t}) \mathrm{u}(C_i) \mathrm{dt} \tag{15}$$

subject to the accumulation equations of its less secure stock of natural resources (14) and its non-resource foreign assets (bonds and imported capital):

$$\dot{F}_i = r\left(F_i - K_i\right) + \mathrm{p}\left(\sum_{j=1}^{N} q_j\right) q_i + K_i^{\alpha}\left(\frac{1}{N}\right)^{1-\alpha} - C_i \ . \tag{16}$$

In solving this dynamic control problem, group *i* takes the oil or gas depleted at any point of time by the other groups in society, i.e., q_j , $j \neq i$, as given. We derive an open-loop Nash equilibrium in terms of the extraction rates to this dynamic game. We assume that the constant world rate of interest r equals the pure rate of time preference ρ, so that it is optimal to smooth consumption over time.[11]

A. *Optimality Conditions for the Dynamic Common-Pool Problem*

The present-value Hamiltonian for group *i* is defined as:

$$\begin{aligned} H_i \equiv \mathrm{u}(C_i) + \lambda_i &\left[r\left(F_i - K_i\right) + \mathrm{p}\left(\sum_{j=1}^{N} q_j\right) q_i + K_i^{\alpha} N^{\alpha-1} - C_i \right] \\ &+ \mu_i \left[-q_i + \sum_{j \neq i} \xi (S_j - S_i) \right]. \end{aligned} \tag{17 }$$

Application of Pontryagin's Maximum Principle yields the necessary conditions for group *i*:

$$\begin{gathered} \mathrm{u}'(C_i) = \lambda_i, \quad \dot{\lambda}_i = 0, \quad \alpha\left(K_i N\right)^{\alpha-1} = r, \quad p\left(1 - \frac{1}{N\eta}\right)\lambda_i = \mu_i, \\ \text{and } \ \rho\mu_i - \dot{\mu}_i = -\xi(N-1)\mu_i, \end{gathered} \tag{18}$$

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[11] If the interest rate exceeds the discount rate, there is an additional incentive to postpone consumption and save. The current account would then be positive as the country builds up assets. One could argue that politicians are for electoral or other reasons short-sighted in which case it may be reasonable to assume that the discount rate exceeds the interest rate. In that case, there is an extra reason to deplete to fast and the inefficiencies highlighted in this paper would be exacerbated.

where $q \equiv \sum_{j=1}^{N} q_j$. Since $r = \rho$, each group attempts to smooth its level of consumption, that is $\dot{C}_i = 0$. The demand for capital follows from setting the marginal product of capital to the world interest rate. Aggregate production and capital are thus given by:

(19) $$K \equiv \sum_{j=1}^{N} K_j = \left(\frac{\alpha}{r}\right)^{\frac{1}{1-\alpha}} \text{ and } Y \equiv \sum_{j=1}^{N} Y_j = \left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha}}.$$

B. *Political Distortions in the Hotelling rule*

We also derive from the last two equations of (18) and the assumption that the foreign price of oil is constant (i.e., $\pi^* = 0$) that the rate of increase in the price of oil exceeds the world rate of interest and thus that depletion of oil reserves is excessively fast:

(20) $$\frac{\dot{p}}{p} = r + \xi(N-1) > r \text{ and } \frac{\dot{q}}{q} = -\eta[r + \xi(N-1)] < -\eta r \text{ if } N>1 \text{ and } \xi > 0.$$

The political common-pool variant of the Hotelling rule (20) and the resource depletion equation $S_0 = \int_0^\infty q(t)dt$ give the initial rate of aggregate resource extraction and the initial priced of natural resources:

(21) $$q(0) = \eta[r + \xi(N-1)]S_0 > \eta r S_0 \text{ and } p(0) = \text{p}\left(\eta[r + \xi(N-1)]S_0\right) < \text{p}\left(\eta r S_0\right) \text{ if } N>1 \text{ and } \xi > 0.$$

Equation (20) is the political common-pool variant of the Hotelling rule. Effectively, $\xi\,(N-1)$ is an intertemporal wedge in the Hotelling rule. Equations (20) and (21) completely define the resource depletion and resource price trajectories. The initial resource depletion rate in a fractionalised society with competing groups is higher and subsequently falls faster than in a homogenous society. The initial resource price is lower and rises at a faster rate than the market rate of interest, which would be the rate of increased in resource prices in a society without rival actions as prescribed by the undistorted Hotelling rule. Hence, after some time as resources become scarcer, resource depletion rates in a fractionalised society become lower and resource prices higher than in a homogenous society. Resource revenues *pq* decline at the rate

$(\eta - 1)[r + \xi(N-1)]$, hence resource revenues decline more rapidly in a more fractionalised society with a high elasticity of demand for its natural resources. These intertemporal distortions are especially high if, on the one hand, there is a lot of seepage of oil or gas between fields or property rights on natural resources are very insecure, and, on the other hand, if there are lots of rival factions having access to natural resources.

C. *Fractionalisation, Sovereign Wealth Funds and Sustainable Consumption*

To obtain the political variant of the Hartwick rule, we proceed in the same manner as in the proof of proposition 1. We thus find that a fractionalised country saves more in foreign bonds than the value of its marginal natural resource rents, especially if seepage is strong, property rights are insecure and the number of rival factions is large. However, as extraction of natural resources occurs too fast in fractionalised economies with insecure property rights, natural resource revenues and thus marginal resource rents decline faster than what is socially optimal. As a result, the country ends up in the long run with lower holdings of foreign assets (i.e., a smaller sovereign wealth fund) and thus with a lower level of sustainable consumption than a homogenous society with secure property rights. We formalise and prove these insights in propositions 2 and 3 below. Somewhat surprisingly, we will show in proposition 4 that, if the appropriate accounting price is used to evaluate the cost of resource depletion, genuine saving is zero both in homogenous societies with secure property rights and in heterogeneous societies with lots of competing of groups, seepage and insecure property rights. Interestingly, this accounting price is less than the market price of natural resources so World Bank figures for genuine saving over-estimate the cost of resource depletion and thus show up negative. In this sense, the negative genuine saving figures reported by the World Bank may thus be an artefact.

Proposition 2: The equilibrium expression for the current account is given by

(22)
$$\dot{F}(\mathrm{t}) = \left[1 + \frac{\xi(N-1)}{\eta r + (\eta-1)\xi(N-1)}\right]\left(1 - \frac{1}{\eta}\right) p(\mathrm{t}) q(\mathrm{t}) > \left(1 - \frac{1}{\eta}\right) p(\mathrm{t}) q(\mathrm{t}) \text{ if } N > 1 \text{ and } \xi > 0, \quad \text{where } F \equiv \sum_{j=1}^{N} F_j .$$

The sovereign wealth fund that the economy ends up with in the long run (SWF) is given by

(23) $$\text{SWF} \equiv \lim_{t\to\infty} F(t) - F_0 = \left[1 + \frac{\xi(N-1)}{\eta r + (\eta-1)\xi(N-1)}\right] \text{p}\left(\eta[r+\xi(N-1)]S_0\right) S_0,$$

where $F(0) = F_0$. The SWF is low if N and ξ are high and if η is high.

Proof: Postulate $\dot{F}(t) = \left(1 - \frac{1}{\eta}\right) p(t)q(t) + X(t),$ where $X(t)$ is an unknown function to be determined. It follows from $\ddot{F} = \left(1-\frac{1}{\eta}\right)(p\dot{q} + \dot{p}q) + \dot{X} = r\dot{F} + \left(1-\frac{1}{\eta}\right)p\dot{q} - \dot{C}$, $\dot{C} = 0$ and the political Hotelling rule (20) that $\dot{X} = rX + \left[r - [r + \xi(N-1)]\right]\left(1-\frac{1}{\eta}\right)pq,$ which can be solved to give $X = \left[\frac{\xi(N-1)}{r + (\eta-1)[r+\xi(N-1)}\right]\left(1-\frac{1}{\eta}\right)pq$ and thus (22). Integrating (22) forwards and making use of the political Hotelling rules (20) and (21), we obtain (23). Differentiating (23), we get $\frac{\partial \text{SWF}}{\partial \xi(N-1)} = -\left(\frac{\xi(N-1)}{\eta\left[r + \xi(N-1)(1-\eta^{-1})\right]^2}\right)\left(1-\frac{1}{\eta}\right)p(0)S_0 \le 0$. It is also straightforward to show that $\frac{\partial \text{SWF}}{\partial \eta} < 0$ even if $\xi(N-1) = 0$. □

Given the optimal expression for the current account (22), we can calculate the constant level of sustainable consumption and show that it is equal to interest on initial foreign assets plus interest obtained on the sovereign wealth fund plus wage income. We show that sustainable consumption is sub-optimally low in a fractionalised economy with seepage or insecure property rights.

Proposition 3: The sustainable level of constant consumption is given by

(24) $$C = rF_0 + \text{W}(r) + \left[\frac{\eta r[r+\xi(N-1)]}{\eta r + (\eta-1)\xi(N-1)}\right]\text{p}\left(\eta[r+\xi(N-1)]S_0\right)S_0$$
$$\equiv \text{C}(\overset{+}{F_0}, \overset{+}{S_0}, \xi(\overset{-}{N}-1), \overset{-}{\eta}) < \text{C}(\overset{+}{F_0}, \overset{+}{S_0}, 0, \eta) = p\left(\eta r S_0\right) r S_0,$$

or, alternatively, by

(24′) $$C = rF_0 + \mathrm{W}(r) + r\mathrm{SWF},$$

where the long-run sovereign wealth fund is given by (23) and $\mathrm{W}(r) \equiv (1-\alpha)Y = (1-\alpha)\left(\frac{\alpha}{r}\right)^{\frac{\alpha}{1-\alpha}}$ with W′<0 stands for the wage bill (i.e., the factor price frontier). Sustainable consumption and the accumulated sovereign wealth fund are lower if there are many competing factions, property rights are more insecure and the country does not enjoy much monopoly power on the market for natural resources.

Proof: Using $\dot{F} = \left(1-\frac{1}{\eta}\right)pq\left[1+\frac{\xi(N-1)}{r+(\eta-1)[r+\xi(N-1)]}\right] = r(F-K) + \mathrm{f}(K) + pq - C$ from (22), $f(K) - rK = (1-\alpha)(\alpha/r)^{\alpha/(1-\alpha)} \equiv \mathrm{W}(r), \mathrm{W}' < 0$ and (21), and evaluating everything at time zero, we obtain $C = rF_0 + \mathrm{W}(r) + \left[1-\frac{\xi(N-1)(\eta-1)}{r+(\eta-1)[r+\xi(N-1)]}\right]p(0)[r+\xi(N-1)]S_0$ which can be rewritten as (24). Since *pq* vanishes in the long run, $C = \lim_{t\to\infty} F(t) + \mathrm{W}(r),$ which amounts to (24′). The comparative statics results follow directly from proposition 2. □

Consumption thus increases one-for-one with wage income and interest earned on initial holdings of foreign assets. Not surprisingly, the sustainable level of consumption increases less than proportional (due to the downward-sloping curve for natural resources) with the initial stock of natural resources. The third term on the right-hand side of (24) indicates the present value of future natural resource revenues. More monopoly power on the oil or gas market (a lower value of η) implies that the groups hold back extraction and thus push up oil or gas prices and revenues. This boosts sustainable consumption in both homogenous and fractionalised societies. The distortion due to infighting between groups in combination with seepage or insecure property rights is lower if the oil or gas market is less competitive. This further boosts sustainable consumption in heterogeneous societies. Our main insight is thus that a more insecure system of property rights or more seepage between the oil or gas fields of the competing factions (higher ξ) and more rival factions (higher *N*) depress the level foreign assets accumulated in the sovereign wealth fund and thus depress the level of consumption that can be sustained.

The coefficient on the term $p(0)S_0$ in (24) is bigger and thus also the annuity value of exhaustible resource assets and the sustainable level of consumption are bigger if there are more rival factions. Basically, the annuity value of exhaustible resource assets exceeds the initial annuity value $rp(0)S_0$ in a fractionalised society. This indicates that the rival factions engage in rapacious rent seeking and consume too much. However, the initial price level of natural resources is lower in a fractionalised country with $N > 1$ than in a homogenous society. This initial price level effect dominates, so that the net effect of an increase in the number of rival factions on aggregative consumption is negative. Fractionalisation thus induces rapacious rent seeking and depresses the sustainable level of consumption. Furthermore, the effect of an exhaustible resource discovery ($S_0 > 0$) on sustainable consumption is smaller for larger N.

Comparing (24) and (24′), we see that it is optimal to gradually transform exhaustible oil or gas reserves into interest-earning foreign assets held in a sovereign wealth fund. Foreign wealth gradually grows from F_0 to $F_0 + \mathrm{SWF}$. The final level of accumulated foreign wealth in a fractionalised society is less than in a homogenous society despite the lower initial price of natural resources. Also, the speed of transformation is faster in a fractionalised society, especially if the elasticity of world demand for natural resources is high. It is the interest that is earned on the sovereign wealth fund that makes up for the dissipating natural resource revenues and is thus what makes it possible to sustain a constant level of consumption as resources get depleted.

With perfectly defined property rights and no seepage or with a homogenous society, the undistorted Hotelling rule holds and the rate at which prices of natural resources increase thus equals the world rate of interest. The size of the sovereign wealth fund therefore corresponds to what the initial stock of natural resources would fetch in the market if it is sold (i.e., with $\xi(N-1) = 0$ one has SWF = $p(\eta r S_0)\, S_0$).

D. *Zero Genuine Saving Even with Seepage or Imperfect Property Rights*

Our economy with competing factions and seepage and/or insecure property rights has an imperfect mechanism for resource allocation and thus yields an inefficient equilibrium allocation with sub-optimally low levels of consumption. We therefore have to be careful in defining the true accounting prices that should be used for calculating genuine saving. We apply the theoretical framework for accounting in economies with imperfect allocation mechanisms developed by Dasgupta and Mäler and (2000), Dasgupta (2001b) and Arrow, Dasgupta and Mäler (2003) to our economy. The proper accounting price that should be used is thus the relative effect of a marginal increase in the initial stock of natural resources on the social objective function divided by the relative effect of a marginal increase in the initial stock of foreign assets on the social objective function. In our framework, the accounting price becomes the effect of a marginal increase in the initial stock of natural resources on the sovereign wealth fund that is accumulated in the long run. With the aid of (24), the accounting price can thus be written as:

(25 $$\left(1-\frac{1}{\eta}\right)p(0) \le p_G(0) \equiv \frac{\partial C / \partial S_0}{\partial C / \partial F_0} = \frac{\partial \text{SWF}}{\partial S_0} = \left[\frac{\eta[r+\xi(N-1)]}{\eta r+(\eta-1)\xi(N-1)}\right]\left(1-\frac{1}{\eta}\right)p(0) \le p(0).$$

In homogenous societies or fractionalised societies with secure property rights the accounting price equals the marginal resource revenue. In economies with very large number of competing factions and highly insecure property rights, the accounting price tends towards the market price of natural resources. In general, the accounting price that should be used to calculate genuine saving is bigger than the marginal revenue and smaller than the market price of natural resources. Supposing that the World Bank uses the market price to estimate genuine saving, their estimates would be too high as the accounting value of resource depletion would be over-estimated albeit less so in more fractionalised economies with more insecure property rights. The negative measures of genuine saving for many resource-rich developing economies calculated by the World Bank are thus likely to be too negative and, according to this political economy view, may even be somewhat of an artefact.

Proposition 4: Using the accounting price (25), aggregate genuine saving is given by

(26) $$GS \equiv \dot{F}(0) + p_G(0)\dot{S}(0) = 0.$$

Genuine saving is thus zero both in homogenous societies with secure property rights ($\xi(N-1) = 0$) and in heterogeneous societies with insecure property rights. Genuine saving figures erroneously calculated with actual market prices will be negative, albeit less so in more fractionalised economies with less secure property rights.

Proof: Using (21) for $\dot{S}(0) = -q(0)$, (22) and (25), we obtain (26). □

We immediately see that genuine saving is zero in a non-fractionalised, homogenous society with only one group ($N = 1$). Genuine saving is also zero in a fractionalised society with no seepage between oil or gas fields and perfectly defined property rights for natural resources. However, figures of genuine saving that are calculated with the relatively high market price rather than the accounting price of natural resources would show up negative.

E. *Summing Up*

When there is a power struggle about the control of natural resources in a resource-rich small open economy, natural resource prices rise faster than suggested by the Hotelling rule. As a consequence, depletion of natural resource reserves occurs excessively fast. The country saves in the short and transient phase more foreign assets than the marginal revenues on natural resources. As natural resource revenues and resource rents dwindle away at a faster rate than in a homogenous society, the economy ends up with lower level of foreign assets in the long run and a lower level of sustainable consumption, especially if property rights are fairly insecure, there are more rival factions and the country does not have much monopoly power on the market for natural resources. The power struggle thus harms social welfare. Still, genuine saving is zero also in fractionalised societies with insecure property rights.[12] Genuine saving figures reported by the World Bank will be negative if market rather than accounting prices are used to evaluate the cost of resource depletion.

So why are reported genuine saving rates so negative? One possibility is the anticipation of better times (e.g., expectation of rising world prices of natural resources or falling production costs) discussed in sections II and III. It is then socially optimal to have negative genuine saving rates. Another possibility is that reported figures are negative, since the market rather than the accounting price is used to evaluate the welfare cost of resource depletion. It is perhaps therefore fortunate that the World Bank has switched terminology from genuine saving to net adjusted saving. It may be worthwhile to dig deeper into the potential political rationales for negative genuine saving. Countries with a lot of fighting about natural resources are more likely to suffer from corruption and erosion of the quality of the legal system, which discourages saving and investment in productive capital (Hodler, 1996). Also, countries plagued by infighting about natural resources suffer from shortsighted politicians who are too much concerned about present rather than future generations. It remains to be seen whether such political considerations can provide a theoretical political economy rationale for the negative genuine saving.

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[12] In a closed economy with competing factions each owning natural resources which are used in production (an extension of Solow (1974)), we also find that genuine saving is zero when the accounting price of natural resource depletion is properly defined even with seepage and imperfect property rights (van der Ploeg, 2008). The accumulation of physical capital and the depletion of resources occur too fast from a social perspective, but are nevertheless in line and thus genuine saving is zero.

V. CONCLUDING REMARKS

The reported *negative* genuine saving rates of many resource-rich countries are often judged to be detrimental to their economic performance. Undoubtedly, many of these economies would perform better if they reinvested their exhaustible resource rents into their economy as suggested by the Hartwick rule. Still, the low saving rates of many resource-rich countries need not necessarily be sub-optimal. It will be in the interest of exhaustible resource exporters to invest less than the Hotelling rents on exhaustible resources if they expect the world price of natural resources to rise in the future. We also show that exhaustible resource exporters delay resource depletion and save less than their Hotelling rents if they expect the world interest rate to increase or the cost of extraction to fall in the future. Although quantitatively the negative effect of extrapolated increases in resource prices on saving is modest, the historical experience of the US suggests that under the right circumstances anticipated falls in the cost of extraction and thus the downward effects on the nation's saving may be substantial. The US supremacy as a mineral producer and the huge falls in the costs of exploration from the mid-nineteenth to the mid-twentieth century was driven by collective learning, leading education in mining, engineering and metallurgy, increasing returns, private initiative and an accommodating legal environment where the US claimed no ultimate title to the nation's minerals (Habbakuk, 1962; David and Wright, 1997; Wright and Czelusta, 2004). There is no reason why forward-looking governments of today's resource-rich economies should not enjoy technical progress in exploration. It would then make sense to not only borrow for the necessary investments, but also to save less than the current Hotelling resource rents in anticipation of falling extraction costs.

Exhaustible resource importers like any other country will want to borrow for temporary needs in public spending and in government investment. However, a huge empirical literature spawned by Feldstein and Horioka (1980) has established that the current account is not optimally used to finance investment. In cross-country regressions investment does not show up with a negative coefficient of one in equations explaining the current account. Domestic saving rather than international borrowing thus seems to a prime driver of investment. If that is the case, this may also cast doubt on whether the Hartwick rule will be followed in practice. Careful econometric work is needed to test whether saving of resource-rich economies reacts one-for-one to marginal Hotelling revenues on exhaustible resource rents.

However, if competing groups in resource-rich economy fight to get a big share of natural resource revenues, they deplete natural resource reserves faster than suggested by the

Hotelling rule. As a result, resource prices rise to fast. This follows from the impatience induced by such power struggles and natural resources with imperfectly defined property rights. To maintain constant private consumption, the country needs to depart from the Hartwick rule and save in the transient phase more than the current marginal Hotelling resource rents. As natural resource revenues dwindle away faster than is socially optimal, a fractionalised country accumulates in the long run less foreign assets than a homogenous society and therefore can only sustain a lower level of consumption. In this very real sense, fractionalised societies are worse off. These political distortions are especially large in countries with a large degree of fractionalisation, poorly developed property rights and not much monopoly power on the market for its natural resources. We have shown that even for countries with many rival resource-owning groups and insecure property rights on natural resources, genuine saving rates should be from a theoretical point of view zero. The negative genuine saving figures reported by the World Bank may be an artefact, since they use the higher market prices rather than the accounting prices to value the cost of resource depletion. It is therefore good that the World Bank has switched terminology from genuine saving to net adjusted saving. In future work we may need to dig deeper into the political failures to explain why observed genuine saving rates are so negative.

More work needs also to be done on how theoretical, normative insights such as the Hotelling rule and the Hartwick rule should be adjusted to be of use in practical policy formulation. For example, natural resource discoveries typically induce governments to engage in exuberant public spending based on the incorrect assumption that windfall natural resource revenues are permanent. This leads to intertemporally unsustainable spending levels with painful adjustments when the resource revenues run out. Alternatively, a faction of natural resource revenues may be siphoned off by the political elite and its cronies and can thus not be used by the people for consumption. This also implies that less of current Hotelling resource rents will be saved. We must therefore abandon the assumption of competitive markets with perfect information and allow for a richer variety of economic and political distortions. It is crucial to investigate how advice on optimal rates of resource depletion, government spending, saving and investment survives in a context where politicians seek office and try to grab resource rents for themselves or to be able to pay off political opponents and are able to get away with it due to poor institutions, bad legal systems and poor checks and balances in the political system. Rapacious rent seeking rather than anticipation of better times may unfortunately be a much more important reason why many resource-rich economies squander their Hotelling rents on exhaustible resources and suffer such disastrous economic and social outcomes.

On a more pragmatic note, the matter of observed negative genuine saving rates is worse for resource-rich countries with high population growth rates. Such countries need *positive* rather than *zero* genuine saving rates to maintain constant consumption per head. The Solow-Swan neoclassical model of economic growth predicts that such countries have lower capital intensities and lower income per capita. In fact, in countries with high population growth rates genuine saving may be positive while wealth per capita declines (World Bank 2006, Table 5.2). Such countries are on a treadmill and need to create new wealth to maintain existing levels of wealth per capita. They thus need to save more than their exhaustible resource rents, but rarely manage that. For example, sub-Saharan Africa has high population growth rates and shows substantial saving gaps of 10 to 50 percent of GNP. For Congo and Nigeria the saving gaps are as high as 110 percent and 71 percent, respectively.

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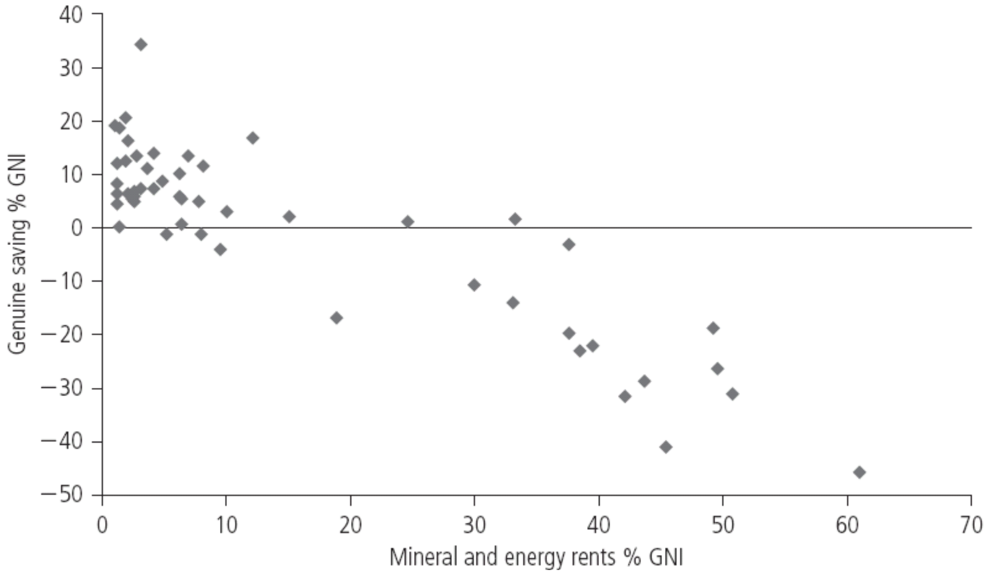
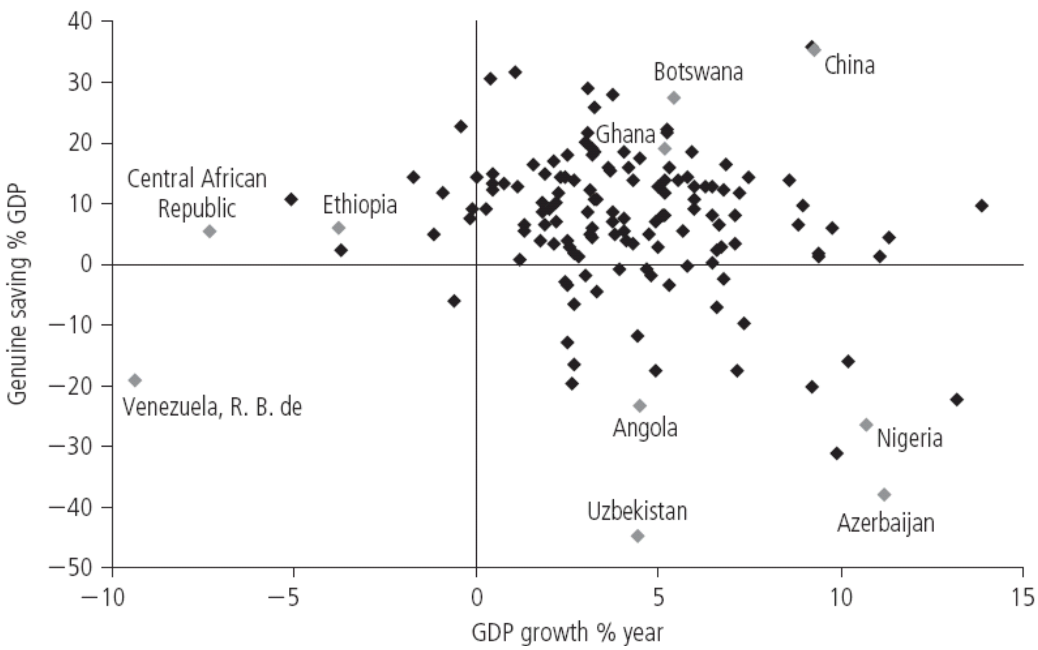
Figure 1: Reported genuine saving and exhaustible resource share



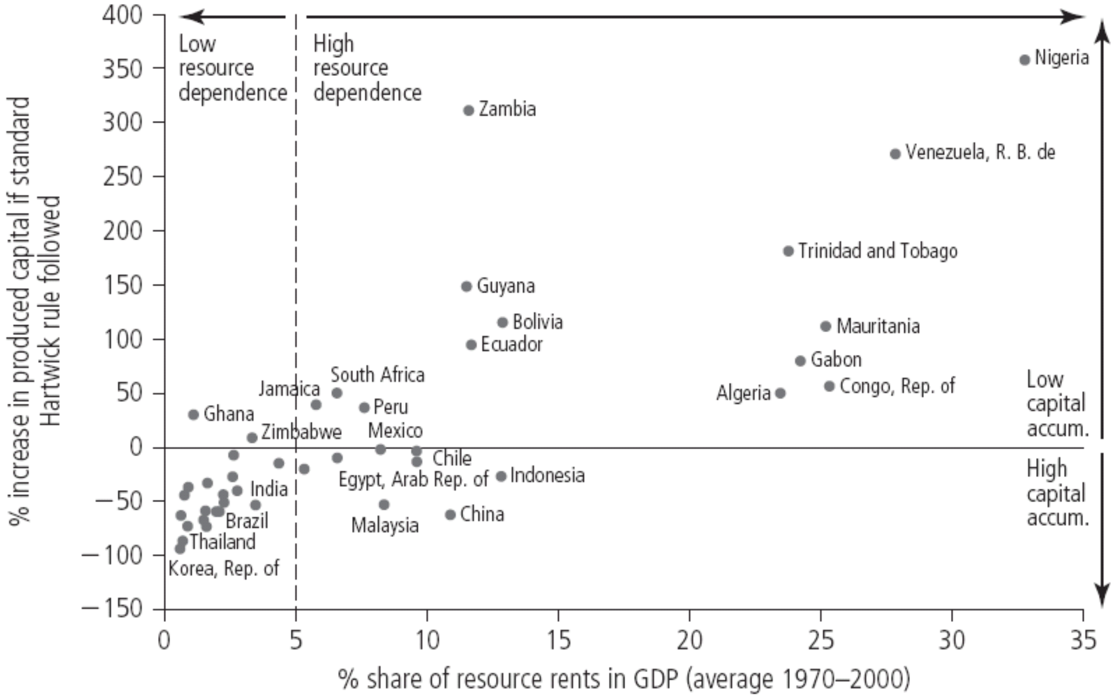
Source: World Bank (2006, Figure 3.4)

Figure 2: Reported genuine saving rates against economic growth, 2003



Source: World Bank (2006, Figure 3.6).

Figure 3: Counterfactual exercise of imposing the Hartwick rule



Source: World Bank (2006, Figure 4.1).