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Resource Rents: When to spend and how to save

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Resource rents; when to spend and how to save

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Abstract

Countries with substantial revenues from renewable resources face a complex range of revenue management issues. What is the optimal time profile of consumption from the revenue, and how much should be saved? Should saving be invested in foreign funds or in the domestic economy? How does government policy influence the private sector, where sustainable growth in the domestic economy must ultimately be generated? This paper develops the issues in a simple two-period model, and argues that analysis must go well beyond the simple permanent income approach sometimes recommended.

Keywords: Natural resources, revenue management, resource curse, permanent income

JEL code: Q32, O11, E2, H0.

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1. Introduction and issues

Extraction of non-renewable natural resources is a dominant feature of some 50 countries, home to 1.4 billion people. Natural resources create income, supply foreign exchange, and provide government revenue, yet their net impact on economic performance has often been negative. Numerous researchers have studied this relationship. Econometric studies tell us that the impact of resources depends critically on the quality of governance, having a negative impact on countries with governance indicators below a certain level. The quality of governance itself can be eroded by resource wealth, creating vicious circles of mis-management and, in the worst cases, conflict. Resource induced volatility has a negative effect and resource booms are short-lived with negative long run effects.¹

Underlying these statistical relationships are two fundamental mechanisms. One is that resources foster rent seeking behaviour of all sorts, so there is no effective government will to use resources to improve economic performance or to benefit the citizenry at large. The other is that – even for a government seeking to bring lasting economic benefit from a resource – it is a difficult task. How should a government use a temporary resource windfall to bring about both short run poverty reduction and a sustainable long run increase in income? The objective of this paper is to bring economic analysis to bear on this question.

We start with a look at the facts and statement of the issues. Table 1 gives the data for the 48 countries for which mineral and hydrocarbon resources generated more than 25% of exports or more than 25% of fiscal revenue during the period 2000-05. The table demonstrates clearly the dominance of natural resources in many of these countries. In 24 countries resources accounted for more than 75% of exports and in 13 more than 40% of GDP. And with respect to fiscal revenue, in 18 countries more than 50% of government income came from resource rents. The ratio of fiscal revenue to exports is much higher for hydrocarbon exporters than for exporters of minerals, at an average of 58% compared with 24%. In Sub-Saharan Africa resource exports amounted to some \$50bn pa, a similar order of magnitude to official development assistance, although

¹ See van der Ploeg (2009) for a survey of the literature on the ‘resource curse’. Collier and Venables (2009) review the literature on resources and governance.

Table 1: Renewable resources; fiscal revenues and exports

		Average Annual Resource Revenues 2000-05		Average Annual Resource Exports (Goods) 2000-05	
		In percent of total fiscal revenue	In percent of GDP	In percent of total exports (Goods)	In percent of GDP
Algeria	Hydrocarbons	70.5	26.3	97.6	36.8
Angola		79.8	33.4	91.8	68.0
Azerbaijan		33.3	8.5	87.3	36.1
Bahrain		71.3	23.2	74.4	53.7
Brunei Darussalam		87.7	40.5	90.1	58.6
Cameroon		27.7	4.8	44.7	8.3
Colombia		10.0	3.0	26.7	4.4
Congo, Rep of		69.6	22.2	88.3	68.7
Ecuador		26.0	6.6	46.9	11.8
Equatorial Guinea		85.2	24.4	96.8	93.1
Gabon		60.1	19.2	81.7	47.5
Indonesia		30.3	5.5	22.8	7.3
Iran		65.5	14.7	82.2	24.2
Iraq		79.2	69.5	97.0	69.4
Kazakhstan		25.1	6.3	52.6	24.1
Kuwait		74.7	46.1	92.2	45.1
Libya		80.2	43.2	97.1	53.6
Mexico		33.3	7.5	17.2	3.0
Nigeria		78.9	32.3	97.2	46.2
Norway		24.0	13.0	60.0	19.8
Oman		83.4	38.6	80.9	45.3
Qatar		68.4	26.0	78.5	46.8
Russia		19.5	7.3	54.0	17.9
Saudi Arabia		83.1	31.3	88.8	39.8
Sudan		49.8	8.3	80.6	12.9
Syria		46.3	12.8	70.2	24.6
Trinidad and Tobago		36.4	9.3	59.9	28.4
Turkmenistan		43.2	8.7	83.5	28.7
United Arab Emirates		66.1	19.7	42.4	32.6
Venezuela		48.8	15.8	82.5	25.8
Vietnam		31.2	7.4	21.3	11.0
Yemen		71.5	24.9	88.1	32.7
Botswana	Diamonds	62.5	20.6	79.5	32.3
Chile	Copper	9.4	2.2	39.1	11.7
Dem. Rep. of Congo	Diamonds	...	...	52.7	11.9
Ghana	Gold	...	...	33.4	11.0
Guinea	Bauxite/alumina	17.8	2.4	87.7	19.0
Kyrgyz Republic	Gold	1.7	0.3	39.1	12.5
Liberia	Diamonds	...	...	...	...
Mauritania	Iron ore	...	...	53.4	16.2
Mongolia	Copper, gold	8.2	2.9	51.2	26.3
Namibia	Diamonds	5.9	1.9	59.9	20.0
Peru	Gold, copper, silver	3.3	1.5	50.8	8.1
Papua New Guinea	Gold	17.9	5.6	77.6	47.9
Sierra Leone	Diamonds, bauxite,	0.9	0.2	87.0	10.1
South Africa	Gold, platinum, coal	...	...	27.2	6.4
Uzbekistan	Gold	...	...	29.8	8.6
Zambia	Copper	...	...	60.5	16.6

Source: IMF (2007)

concentrated in countries with about one-third of the region's population. The flows are of course volatile, moving with resource prices. The period 2000-05 was one in which oil prices averaged just over \$30 per barrel so oil exports – and the share of rents in these exports – have reached significantly higher levels since then.

Economic analysis of natural resource revenues can be divided into three very broad issues. The first is to do with designing and implementing fiscal regimes and contracts with the investors who undertake prospecting, development of new fields or mines, and extraction. This is complex because they have to meet multiple objectives. One is to capture rent for the government, and another is to leave incentives for efficient extraction and for investment in exploration and development. Contracts typically take the form of an initial payment for the license and then operate subject to a royalty (or production sharing agreement) and corporate profits taxation, possibly at a sector specific premium rate. This is an environment of very long term projects with high initial costs; a mine may easily last for 50 years or more, and up front capital costs are truly sunk, having little or no alternative use value. Furthermore, there is uncertainty about future price paths and about geology, and also asymmetric information, with the investor better informed about geology and technology than is government. There are examples where government take has been too low (such as Zambia's 0.8% royalty on copper, Adam and Masonda 2009), while government take on other commodities has been much higher (in excess of 70% on most oil contracts and for Botswana's diamonds). It is likely that contracts have systematically failed to provide sufficient incentive for prospecting and new investments. There is a fundamental hold-up problem, as government cannot commit not to renegotiate contracts and fiscal terms once investments are sunk. Investors are deterred, and resource producers themselves are the ultimate losers from this inability to commit. This affects developing countries in particular; Collier (2010) points to the fact that known subsoil mineral assets in the OECD are \$114,000 per km sq, but in Africa are only \$23,000.

The second issue is to do with the transparency, honesty, and efficiency with which the state handles the revenue and spending from it. Estimates for Nigeria suggest that direct theft of oil ('bunkering') is running at several billion dollars per year, and cumulative historical theft of resource revenues is many times this. A recent study of Cameroon 1977-2000 (Gauthier and Zeufack 2009) finds that a sizeable portion of oil rent (67%) was captured by the state, but only 39% of government oil revenues were transferred to the budget. The remaining 61% is

unaccounted for. Rent seeking activity has proliferated, ranging from the wasteful (diversion of entrepreneurial skills into rent seeking activities) to the damaging (undermining governance) and the dangerous (conflict). There is evidence that corruption is positively associated with resource rents (Bhattacharyya and Hodler 2009). Both the probability of civil conflict commencing and the duration of conflict are positively linked to resource booms (Besley and Persson 2008). Resource wealth creates both the incentive to try and take over the state and, in some cases, the means to finance insurgency.

The third area is to do with the macro-economics of revenue management. What should be the time profile of consumption and of saving and, if saving is taking place, what form should this take? Standard analysis of this question (such as that offered by the International Monetary Fund, e.g. Davis et al., 2002; Barnett and Ossowski, 2003) is based on the permanent income hypothesis (PIH), which suggests that saving should be such as to hold constant the level of resource wealth plus accumulated savings, with consumption just equal to the interest on this stock of wealth. In the simplest versions, these savings should be held abroad, in a Sovereign Wealth Fund (SWF) which will provide income for future generations. The PIH provides an important benchmark, and points to the importance of saving from resource revenues. It is certainly the case that many developing countries have saved too little of their resource revenues. However, we argue that the PIH is inappropriate for developing countries for several reasons.

A key feature of a developing country is shortage of capital of all sorts. This includes lack of public capital such as infrastructure, and publicly funded capital such as education and health.² Resource revenues provide a way of relaxing these constraints and financing public investment in such capital. Analysis should take this into account particularly since, as the data of table 1 indicates, resource revenues contribute significantly to the supply of public funds. One of the benefits of a larger stock public and human capital is that it will raise the productivity of private capital. It is also possible that resource wealth reduces the cost of capital for the private sector; in an economy that is borrowing on international capital markets a resource windfall may improve creditworthiness and lower borrowing rates on world markets. Together, these effects of higher capital productivity and lower borrowing costs can boost private investment and enable capital deepening in the domestic economy.

² Investment in infrastructure in the fastest growing economies has averaged around 5-7% of GDP, as compared to a developing country average of 2%, World Bank (2008).

As well as being capital scarce, developing countries have urgent needs for poverty reduction, suggesting that revenue should be used to increase the consumption of the current generation. The same point can be put more formally as follows: as some resource revenues are used to raise capital stocks so interest rate should decline, meaning that consumption should (according to the Ramsey rule) move to a flatter time path. Revenues should therefore be used to fund an upwards jump in consumption, as well as capital accumulation. Clearly, there is a trade-off here, and an optimal balance between capital deepening and incremental consumption needs to be found.

Together, these arguments suggest that the time profile of incremental consumption and saving, as well as the composition of saving (foreign assets vs domestic public or private capital) should be quite different from that suggested by the PIH. A developing country should both devote somewhat more of the windfall to present consumption than is suggested by the PIH, and have a composition of saving that is much more skewed towards capital accumulation in the domestic economy. Furthermore, the interaction between private and public sector decision taking is crucial. While government is the recipient of resource rent it is ultimately the private sector that will make the investment decisions required to get sustained growth from resource wealth. The way in which government can – and cannot – influence private sector behaviour is therefore central to the problem.

The objective of this paper is to investigate the optimal use of resource revenues, recognising these features. The paper develops the simplest possible two-period model, and does not seek to fully endogenise all the imperfections.³ The focus is on studying how government should handle a resource windfall in a developing country with the characteristics sketched above, and how policy advice needs to go beyond the simple PIH. The next two sections present the analysis, and a final section discusses the way in which they illuminate the experience of countries that are seeking to manage their resource revenues.

³ Some of these are modelled more fully in van der Ploeg and Venables (2008). In this normative treatment of the issues we abstract from political economy issues and analyse policy for a welfare maximising government.

2. Consuming and investing: a two-period model

A two period model provides the simplest framework within which to explore the savings and investment choices faced by government. The ingredients of the model are as follows. There is a single non-resource good that can be produced by the economy. It is tradable and its price is set at unity. The production function is $Y(K, G)$, where K is the stock of private capital and G is the stock of public capital. Labour input is assumed to be fixed and is suppressed in the notation. The function is increasing and concave in both capital stocks and K and G are complements, so $Y_{KG} > 0$ (letter subscripts denote partial derivatives). In the first period we take these stocks to be given, so first period output is $\bar{y} = Y(\bar{K}, \bar{G})$. Investment takes place during the first period, increasing private capital by k and public capital by g , so second period output is $y(k, g) \equiv Y(\bar{K} + k, \bar{G} + g)$, with marginal products $y_K(k, g)$, $y_G(k, g)$.⁴ The economy also receives lump sum resource revenue in each period N_1, N_2 .

The period one budget constraint for the economy as a whole is

$$a_1 = \bar{y} + N_1 - c_1 - k - (1 + \lambda)g, \quad (1)$$

where c_1 is consumption and a_1 is accumulation of foreign assets.⁵ Public investment g has full cost $(1 + \lambda)g$, where λ is the shadow premium on public funds. We do not endogenise this, but merely assume that spending on public capital may face an additional cost, perhaps due to distortions induced by taxation, or simply because of losses in the tax collection process. For the moment, we write the budget constraint for the economy as a whole, but in later sections split it between the public and private sectors. The second period budget constraint is

$$c_2 = y(k, g) + N_2 + r^* a_1, \quad (2)$$

where no wealth is carried beyond period two, and r^* is one plus the interest rate that the economy faces. This is the rate at which the economy can borrow or lend. We will refer to it as

⁴ For simplicity we ignore depreciation. Because of fixed labour force there are decreasing return to K and G together.

⁵ We set initial holdings of foreign assets/ debt at zero.

the foreign interest rate, and think of it as the world rate of interest plus a country specific premium. This may depend on perceived country risk; there is evidence that the rate is higher for countries with more foreign debt (Akitobi and Stratmann 2008). In this paper we do not model this premium endogenously, but we suppose that resource revenues may reduce it as the wealth of the country is increased; we analyse the effects of any such change.

The social objective is

$$W = u(c_1) + u(c_2) / \rho \quad (3)$$

where ρ is (one plus) the rate of social time preference and $u(\cdot)$ is the strictly concave instantaneous utility function. Using (1) and (2) in (3) gives

$$W = u(c_1) + u\left(y(k, g) + N_2 + r^* [\bar{y} + N_1 - c_1 - k - (1 + \lambda)g]\right) / \rho. \quad (4)$$

The social optimum:

We look first at optimal policy when government directly controls private and public behaviour. The social planner's problem is to choose first period consumption and investment, c_1, k, g , to maximise W , and first order conditions are

$$u'(c_1) = (r^* / \rho) u'(c_2), \quad (5)$$

$$y_K(k, g) = r^*, \quad (6)$$

$$y_G(k, g) = (1 + \lambda)r^*. \quad (7)$$

The first equation lines up the intertemporal marginal rate of substitution with the foreign interest rate r^* . We will generally think of r^* as exceeding the rate of pure social time preference, ρ , capturing capital scarcity of the economy. As a consequence, consumption is on a rising path, $c_2 > c_1$. The other two conditions give the levels of investment that line up the marginal products of each sort of capital, $y_K(k, g), y_G(k, g)$, with the foreign rate of interest, factoring in the cost of public funds, λ .

How are choices affected by a windfall? For concreteness and in the illustrations that follow we will assume that the windfall accrues entirely in the first period, so $N_1 > 0$, $N_2 = 0$. We will illustrate results in figures such as figure 1, giving the changes to consumption and investment associated with N_1 going from zero to positive. The first four columns give the first period use of the windfall, i.e. changes in foreign asset accumulation, Δa_1 , in public capital, Δg , in private capital, Δk , and in first period consumption, Δc_1 . These changes are measured as a share of N_1 , so the first four columns sum to unity if $\lambda = 1$ (see budget constraint (1)), and tell us how the windfall is allocated. The final bar gives the change in second period consumption, Δc_2 . The figure is constructed for an example with Cobb-Douglas technology and iso-elastic preferences.⁶

The benchmark case is the permanent income hypothesis. If the windfall has no effect on the foreign interest rate ($\Delta r^* = 0$) or the shadow premium on public funds ($\Delta \lambda = 0$) then it has no effect on k or g , and hence no effect on the production side of the economy, as is clear from equations (6) and (7). Consumption in both periods increases in order to maintain equation (5). This is, generally, not an equal increase in both periods⁷; if utility functions are iso-elastic there is an equi-proportionate increase in both periods' consumption. If $N_1 > 0$, $N_2 = 0$, then the extra second period consumption is financed by carrying forward foreign assets (or lower foreign debt), so $a_1 > 0$. This is illustrated in the first panel of figure 1. There is no change in investment in the domestic economy, 48% of the windfall is invested abroad, and 52% is consumed in the first period. Consumption is on a rising path, so equiproportionate increases give a larger absolute increase in period 2 than in period 1, as illustrated.

⁶ Shares of private and public capital are both set at 0.175; this gives quite sharp diminishing returns to each sort of capital, without which the composition of investment would change more dramatically than is illustrated in the figures. The utility function is isoelastic with exponent 0.75. $\lambda = 0.2$, $\rho = 1.5$, $\delta = 1.65$, $r^* = 1.7$. N_1 is 25% of initial income and resource revenues reduce λ to 0.1 and r^* to 1.68.

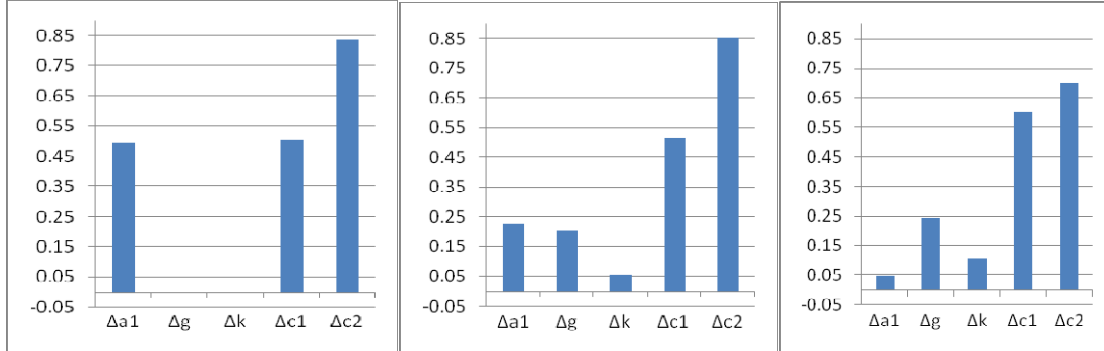
⁷ It will be equal if utility is exponential.

Figure 1: Changes in consumption and investment; the social optimum.

$$N_1 > 0, \Delta\lambda = 0, \Delta r^* = 0.$$

$$N_1 > 0, \Delta\lambda < 0, \Delta r^* = 0.$$

$$N_1 > 0, \Delta\lambda < 0, \Delta r^* < 0.$$



The permanent income hypothesis provides this benchmark case, but implies no change whatsoever in the production side of the economy or in non-resource income. This is because it fails to capture the possibility that resource wealth can relax two key constraints present in developing economies. The first is the fiscal constraint and associated shortage of public funds. We capture the impact of resource revenues on this simply by supposing that a direct effect of the windfall is to reduce the shadow cost of public funds, λ . The second constraint is capital scarcity, and we capture the impact of resource wealth by supposing it reduces the foreign interest rate faced by the economy, r^* . As outlined above, we do not model these changes, but simply take them as exogenous and focus on their effects. Taking these changes in turn, effects are clear from the first order conditions (5) – (7). The increased availability of public funds (lower λ) makes it optimal to increase public investment, g . And since public and private investments are complementary this raises the return to private capital, so k increases to maintain equation (6). This is as illustrated in the second panel of figure 1. The point to note is that while the total saving out of resource revenue ($\Delta a_1 + \Delta k + \Delta g$) barely changes⁸ the composition of investment changes completely. Accumulation of foreign assets is much less, and instead the economy builds its stock of infrastructure which in turn causes higher investment in private capital, k .

⁸ There is a very small increase in consumption in both periods because of the direct efficiency improvement associated with the fall in λ .

Reducing the rate of interest which the economy faces on international capital markets, r^* , has a direct effect on the first order conditions for both k and g . The reduction in the cost of borrowing increases k and further increases g , effects that are reinforcing because of the complementarity between the two sorts of capital. However, while the composition of investment switches further towards the domestic economy, the total level of saving goes down. The lower interest rate flattens the consumption path, so the effect of the windfall is now to increase consumption in period 1 by more than in the previous two cases, with correspondingly smaller increase in period 2, as illustrated in the third panel of figure 1. The interpretation of this is that relaxing the capital scarcity constraint (lower r^*) makes it efficient for the economy to devote more to raising the consumption of the current (poor) generation, leaving somewhat less for the future (rich) generation. In a continuous time model this means that the resource revenue enables the economy's development path to be brought forward; higher levels of consumption are attained sooner rather than later.⁹

The main messages that come from this simple analysis are: first, that the PIH rule of investing overseas in order to secure a foreign income flow that maintains future consumption is optimal only if the windfall has no effect on key constraints facing developing economies, a high premium on public funds and a high cost of capital. If the windfall reduces the cost of public funds (while holding r^* constant) then it changes the composition but not the level of saving, leading to accumulation of domestic capital rather than foreign assets. If the windfall reduces the cost of capital faced by the economy on world markets then, as well as further increasing investment in the domestic economy, it leads to a larger increment in current consumption and somewhat smaller savings rate. The proportion of the windfall accumulated in foreign assets becomes very small.

⁹ See van der Ploeg and Venables (2008).

Uncertainty about resource revenues:

Full treatment of uncertainty of future resource revenues is beyond the scope of this paper, but a few remarks can be made.¹⁰ Suppose that second period resource revenues, N_2 , are a random variable. Inspection of equations (4) – (7) indicates that the only effect this has on the analysis is to insert the expectations operator in equation (5). N_2 enters c_2 additively and we have

$$u'(c_1) = (r^* / \rho) E u'(c_2). \quad (5')$$

Increasing the variability of N_2 makes it optimal to save more if $u'(\cdot)$ is convex, i.e. $u''' > 0$.

Risk aversion alone does not induce more saving. As explored by Kimball (1990), it is the third derivative of the utility function or ‘prudence’ that induces precautionary saving.

3. Public interaction with the private sector

In the previous section government had perfect control of private sector behaviour or, equivalently, objectives and constraints were perfectly aligned so the social optimum could be decentralised by private behaviour. This is generally not the case; there are likely to be numerous market failures causing the two to diverge. We focus on just one, the possibility that private households have a higher rate of time preference than does society. This might be because of low inter-generational altruism meaning that households place less weight on the well-being of future generations than is socially optimal, or because of private sector uncertainty about the distribution of future revenues. We therefore take private preferences to be

$$V = u(c_1) + u(c_2) / \delta \quad (8)$$

with $\delta \geq \rho$. We retain our normative framework investigating socially optimal policy, but now model this as a two stage game. At the second stage the private sector chooses its consumption and investment c_1 , c_2 and k to maximise its objective, V . At the first stage government chooses public investment g and transfers (taxes or subsidies) to the private sector, understanding the effects these will have on private sector behaviour. We look at two cases, the first in which both

¹⁰ See Gelb and Grassman (2008) for a simple model focusing on the effect of volatility.

the public and private sector have access to international capital markets. This is the simpler case, and enables us to draw out some messages about Ricardian equivalence. We then restrict private access to international capital markets, giving a richer picture of the ways in which government can influence private behaviour.

Private access to international capital markets.

If the private sector has access to international capital markets its budget constraint can be written immediately as

$$c_2 = y(k, g) + s_2 + r^* [\bar{y} + s_1 - c_1 - k]. \quad (9)$$

The private sector does not receive resource revenue directly, but instead gets lump sum transfers s_1 and s_2 from government in periods 1 and 2 respectively. It finances investment in private capital, k , and lends/ borrows internationally any excess of period 1 income over expenditure. Substituting this in the private objective,

$$V = u(c_1) + u(y(k, g) + s_2 + r^* [\bar{y} - c_1 - k + s_1]) / \delta. \quad (10)$$

The private sector chooses consumption and k , taking as given government policies, so first order conditions are

$$u'(c_1) = (r^* / \delta) u'(c_2) \quad (11)$$

$$y_k(k, g) = r^*. \quad (12)$$

The government chooses subsidy levels and public infrastructure at the first stage of the game, knowing that private sector behaviour changes in response to policy. Public infrastructure changes private investment from (12) according to

$$dk / dg = -y_{kG} / y_{kK} > 0. \quad (13)$$

Consumption changes satisfy the private budget constraint (9) and first order conditions (11) and (12). Working this through, the effect of policy changes dg , ds_2 and ds_1 on period 1 consumption is given by

$$dc_1 \left\{ r^* + \left[\frac{u''(c_1)\delta}{u''(c_2)r^*} \right] \right\} = \left\{ [r^* - y_K] \frac{y_{KG}}{y_{KK}} + y_G \right\} dg + ds_2 + r^* ds_1 . \quad (14)$$

Terms in the curly brackets are positive, so first period consumption is increasing in public investment and in transfers. Future transfers have a positive effect on current consumption because the private sector can borrow / lend.

The government's problem is to choose s_1 , s_2 and g to maximise welfare, knowing the private sector responses given in (13) and (14). Welfare is

$$W = u(c_1) + u(c_2) / \rho = u(c_1) + u(y(k, g) + s_2 + r^* [\bar{y} - c_1 - k + s_1]) / \rho . \quad (15)$$

The objective is identical to that of the private sector (10), except that it replaces discount factor δ by ρ . Optimisation is subject to the government budget constraint

$$s_2 = N_2 + r^* [N_1 - (1 + \lambda)g - s_1] , \quad (16)$$

and to the endogenous response of private sector consumption and investment to changes in policy. Substituting constraint (16) into (15) the government's problem is simply to choose g to maximize

$$W = u(c_1) + u(y(k, g) + N_2 + r^* [\bar{y} + N_1 - c_1 - k - (1 + \lambda)g]) / \rho . \quad (17)$$

Notice that the transfers s_2 and s_1 have dropped out of this expression. This reflects the fact that consumers are fully Ricardian; they care only about the present value of transfers from government, $s_2 + r^* s_1$, and they understand the government budget constraint, knowing that a

change in spending on public capital is linked to a change in the present value of transfers $ds_2 + r^* ds_1 = -r^* (1 + \lambda) dg$. The government therefore chooses g , giving first order condition

$$\left[y_G - (1 + \lambda)r^* \right] u'(c_2) / \rho + \left[u'(c_1) - \left(\frac{r^*}{\rho} \right) u'(c_2) \right] \frac{dc_1}{dg} + \left[y_K - r^* \right] \frac{dk}{dg} = 0 \quad (18)$$

with c_1 and k moving according to (13) and (14). However, since $y_K(k, g) = r^*$ (equation 12) and $ds_2 + r^* ds_1 = -r^* (1 + \lambda) dg$ (from the government budget constraint 16), equation (14) reduces to

$$\frac{dc_1}{dg} \left\{ r^* + \left[\frac{u''(c_1)\delta}{u''(c_2)r^*} \right] \right\} = y_G - r^* (1 + \lambda). \quad (14')$$

Inspection of (14') and (18) indicates that the first order condition is satisfied by $y_G = r^* (1 + \lambda)$, and $y_K(k, g) = r^*$. Summarizing, optimal values of c_1 , c_2 , k and g are implicitly defined by

$$u'(c_1) = (r^* / \delta) u'(c_2) \quad (11)$$

$$y_K(k, g) = r^* \quad (12)$$

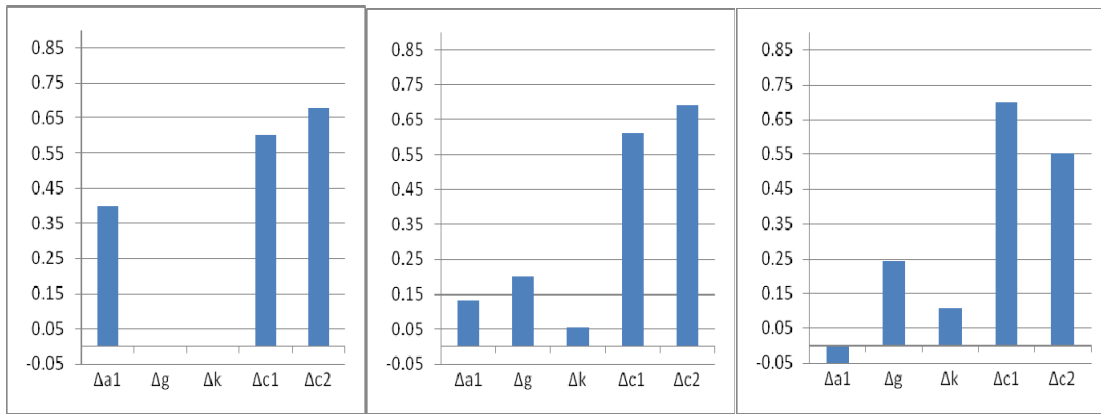
$$y_G(k, g) = (1 + \lambda)r^*. \quad (18')$$

Evidently, levels of physical capital stocks are the same in this case as the fully controlled case of section 2. However, government is unable to influence the time path of consumption which is set by private consumers according to (11). Since $\delta > \rho$, a higher fraction of the windfall is consumed in period 1 than is (first best) socially optimal and, correspondingly, accumulation of foreign assets is less. This is illustrated in figure 2, which is analogous to figure 1. We see that a higher fraction of the windfall goes into immediate consumption (some 60%), less into acquisition of foreign assets, and there is correspondingly less available for future consumption. As before, if the effect of the windfall is to reduce the marginal cost of public funds (centre panel), then it changes the composition of saving; there is an increase in public capital which

induces (according to (13)) an increase in investment in private capital. The final panel shows how, if resource revenues reduce r^* , there may be a larger increase in consumption in the first period than in the second, and the economy may borrow abroad to finance domestic investment and this first period jump in consumption.¹¹

Figure 2: Changes in consumption and investment; Ricardian consumers

$N_1 > 0, \Delta\lambda = 0, \Delta r^* = 0.$ $N_1 > 0, \Delta\lambda < 0, \Delta r^* = 0.$ $N_1 > 0, \Delta\lambda < 0, \Delta r^* < 0.$



Underlying these changes in consumption and asset accumulation are transfers from the government to the private sector and changes in public and private holdings of foreign assets/debt. However, only the present value of transfers, $s_2 + r^* s_1$, matters, so changes in s_1 and s_2 that hold this present value constant have no effect. Any increase in s_1 and corresponding decrease in s_2 will be perfectly matched by an increase in private (and reduction in public) holdings of foreign assets, and optimal values of s_1 and s_2 are indeterminate. This has the important implication that the government may be acting in a manner that appears to be extremely prudent, for example setting $s_1 = 0$ and using all the proceeds for investment in public infrastructure and foreign assets. However, the private sector foresees the consequent second period transfer, s_2 , and plans consumption accordingly, possibly borrowing abroad to finance this consumption. Any increase in government accumulation of foreign assets is exactly offset by the

¹¹ If the change in r^* was an endogenous function of the level of foreign assets/debt then the equilibrium outcome would be a smaller reduction in r^* such that some acquisition of foreign assets still occurs.

opposing change in private behaviour. This case therefore lays out, in very stark terms, the possibility that government behaviour is undermined by private behaviour. Any analysis that focuses exclusively on public sector behaviour may be completely misleading.

Capital controls.

The assumption that the private sector could borrow freely on international capital markets is extreme, and is inappropriate for many developing countries. We therefore look now at a case with a restricted set of options for making intertemporal transfers, assuming that the private sector is able to invest in domestic capital, but not abroad. As a consequence it is unable to completely undo government actions. Government has some ability to manipulate private savings rates and distorts its investments away from productive efficiency to achieve this.

Formalizing this, consumption in each period is $c_1 = \bar{y} + s_1 - k$, $c_2 = y(k, g) + s_2$, where k is the only way for private individuals to transfer wealth between periods. We can eliminate k and capture private sector behavior as the choice of c_1 to maximize

$$V = u(c_1) + u(y(\bar{y} - c_1 + s_1, g) + s_2) / \delta \quad (19)$$

giving first order condition

$$u'(c_1) = (y_K / \delta) u'(c_2). \quad (20)$$

As expected, the time profile of consumption now depends on the rate of return on domestic capital relative to the private sector's rate of time preference.

The government's budget constraint is as before, $s_2 = N_2 + r^* [N_1 - (1 + \lambda)g - s_1]$ so, using this to eliminate s_2 , its problem is to choose s_1 and g to maximise

$$W = u(c_1) + u(y(\bar{y} - c_1 + s_1, g) + N_2 + r^* [N_1 - (1 + \lambda)g - s_1]) / \rho \quad (21)$$

taking into account the endogeneity of c_1 and hence also private investment. First order conditions are

$$\left[y_G - (1 + \lambda)r^* \right] \frac{u'(c_2)}{\rho} + \left[u'(c_1) - \left(\frac{r^*}{\rho} \right) u'(c_2) \right] \frac{dc_1}{dg} = 0 \quad (22)$$

$$\left[y_K - r^* \right] \frac{u'(c_2)}{\rho} + \left[u'(c_1) - \left(\frac{r^*}{\rho} \right) u'(c_2) \right] \frac{dc_1}{ds_1} = 0. \quad (23)$$

The private sector responses dc_1/dg and dc_1/ds_1 come from (19) and the budget constraint and take the form,

$$\frac{dc_1}{dg} \left\{ y_K + \left[\frac{u''(c_1)\delta}{u''(c_2)y_K} \right] + \left[\frac{u'(c_2)y_{KK}}{u''(c_2)y_K} \right] \right\} = \left\{ y_G - r^*(1 + \lambda) + \left[\frac{u'(c_2)y_{KG}}{u''(c_2)y_G} \right] \right\} \quad (24)$$

$$\frac{dc_1}{ds_1} \left\{ y_K + \left[\frac{u''(c_1)\delta}{u''(c_2)y_K} \right] + \left[\frac{u'(c_2)y_{KK}}{u''(c_2)y_K} \right] \right\} = \left\{ y_K - r^* + \left[\frac{u'(c_2)y_{KK}}{u''(c_2)y_K} \right] \right\}. \quad (25)$$

Equations (22) and (23) capture the way in which government distorts the economy away from productive efficiency in order to partially correct the distortion in intertemporal consumption. Results come from looking in the neighbourhood of productive efficiency, i.e. using $y_K = r^*$ and $y_G = r^*(1 + \lambda)$ in the equations above. It is apparent from (24) and (25) that, in this neighbourhood, $dc_1/dg < 0$ and $dc_1/ds_1 > 0$ ¹². With $\delta > \rho$ and (20), the first order conditions (22), (23) will therefore be satisfied with $y_G < r^*(1 + \lambda)$ and $y_K > r^*$.

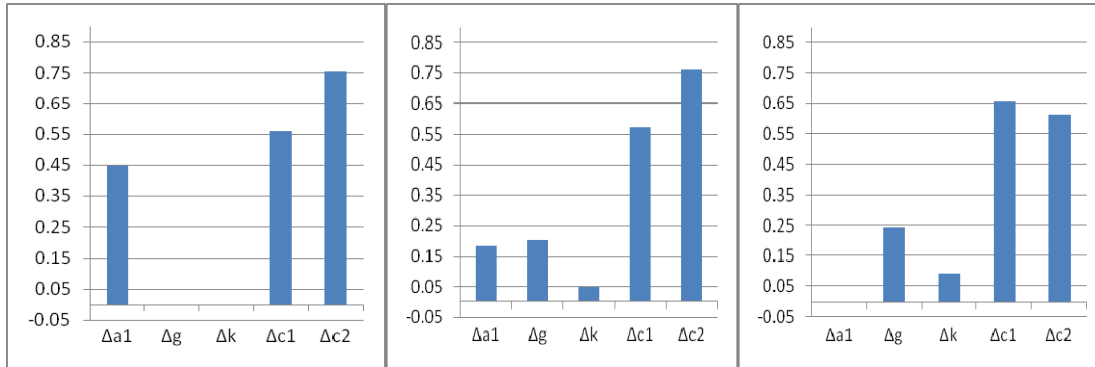
The interpretation of these inequalities is as follows. Government is seeking to increase saving, since the basic distortion is the private sector's high rate of time preference. It does this by committing a relatively high level of public infrastructure, g , which brings the marginal product of public capital y_G below the level required for productive efficiency. Complementarity of public and private capital has the effect of raising the return to private investment, y_K , this being the price through which government raises private saving.

¹² Curly brackets on the left hand side of these equations are positive. The right hand side of (24) is positive since $y_{KG} > 0$, while the right hand side of (25) is negative since $y_{KK} < 0$.

These arguments apply to levels of capital stocks, with or without resource revenues. The effect of the change in N_1 on changes in capital stocks and other endogenous variables is illustrated in figure 3.¹³ Comparison with figures 1 and 2 shows that total saving from the windfall (and hence the change in c_1) lies between the earlier cases, indicating that it is optimal for government to get partial, but not complete control over saving. Comparing the third panel of the figures, the share of resource revenues that is saved is 40% in figure 1, 30% in figure 2, and 34% in figure 3. The change in foreign asset accumulation, Δa_1 , also lies between the two previous cases. However, the main change in the composition of incremental saving is an increase in g relative to k , rather than an increase in both, this having the effect of moving marginal products in the direction required. ‘Over’-investment in public capital is the means through which the government raises private investment and moves the profile of private consumption closer to the first best social optimum.

Figure 3: Changes in consumption and investment; capital controls

$N_1 > 0, \Delta\lambda = 0, \Delta r^* = 0.$ $N_1 > 0, \Delta\lambda < 0, \Delta r^* = 0.$ $N_1 > 0, \Delta\lambda < 0, \Delta r^* < 0.$



4. Implications

The analysis presented above is constructed to be as simple as possible, yet has some important messages for resource revenue management. The first concerns the widespread use of the

¹³ Analytically, the change comes from differentiating first order conditions (20), (22), (23) and (24), (25), with respect to N_1 , λ , and r^* .

permanent income hypothesis (PIH) as the guideline that countries should follow. It is certainly true that savings rates out of resource revenues have been too low in many developing countries; Ossowski et al (2008) estimated that the average change in government expenditure per unit change in resource revenue was 93% during the period 1974-81, although had dropped to 50% during 2000-05. Following from this, countries have been advised to invest resource revenues in foreign assets through a Sovereign Wealth Fund (SWF), only consuming the permanent interest accruing on resource wealth. An even more conservative version of this that has been recommended is the 'bird in hand' rule (Bjerkholt, 2002), according to which resource revenues should be placed in a SWF and countries should only consume interest earned on the SWF (i.e. not consume imputed interest on the value of the resource still in the ground). The analysis of section 2 indicates that if resource revenues relax constraints that are likely to be present in developing countries (scarcity of capital and scarcity of public funds) then the composition of saving should change dramatically, in favour of domestic investment. The level of saving should also be somewhat lower than under the PIH, as the time profile of consumption becomes flatter; it is optimal to bring forwards development and raise further the consumption of the present generation at the expense of future generations who, in a growing economy, will in any case be richer. These arguments are likely to be reinforced by other characteristics of developing economies that are not modelled here. In particular, widespread un- or under-employment of labour increases the social value of investments that create jobs in the domestic economy. Furthermore, it is preferable to distribute resource rents through employment than as rentier income.

While the arguments presented here make the case for investment in the domestic economy rather than in a long term SWF or inter-generational savings funds, foreign funds are still useful for more short term investments. They should be used to cushion volatility in prices and revenue streams, and to 'park' funds if the return on domestic assets is too low, e.g. because of absorption problems in the domestic economy (see van der Ploeg and Venables 2010). Policy makers need to make a clear distinction between the different roles of long run SWFs and shorter run stabilisation funds.

The second main message concerns the relationship between the private and public sectors. Private sector investment is the ultimate mechanism through which resource wealth can bring about sustained growth and employment creation, but neither this nor its counterpart,

private consumption, are directly controlled by government. Much policy advice has focussed on government prudence, but this can easily be undone by private sector behaviour. Kazakhstan provides a telling example. The government has sought to be prudent, establishing an SWF (the National Oil Fund) in which some 2/3rds of resource revenues have been deposited in recent years. The fund and foreign exchange reserves totalled \$50 bn by the end of 2008, compared with total government oil receipts of \$32bn between 1999 and 2007 and GDP approaching \$100bn. However, despite this accumulation of foreign assets by government the country ran a current account deficit throughout the period as the banking sector raised some \$50bn from international capital markets. Most of these funds were lent on for consumption and for housing which increased residential construction but also financed house price inflation. The combined net external debt of the private and public sectors actually increased during the period when the government was acting prudently.

The models we constructed in section 3 shed some light on this experience. The basic point is Ricardian equivalence, under which private sector expectations and ability to borrow can completely undermine government actions. If the private sector has a higher rate of time preference than government, then it will borrow to finance current consumption, just as was the case in Kazakhstan. This points to the fact that policy design must be informed by an accurate assessment of the constraints under which the private sector operates, and of the instruments through which government can channel resource revenues. As we saw in section 3, full Ricardian equivalence disappears if the private sector is able to invest in the domestic economy but does not have access to international capital markets. In practise domestic capital markets are likely to be thin and different firms and households are likely to have quite different investment opportunities. The extent to which transfers from resource wealth are spent or saved depends on these opportunities.

Governments also have a wider range of policy instruments than we have captured here. The family of models presented in the paper give government just three alternative ways of handling resource revenues; purchase of foreign assets, construction of public infrastructure, or non-distortionary transfers to the private sector ('citizen dividends'). In reality government faces a richer menu of choices. Resource revenues provide an opportunity to reduce tax distortions. Transfers to citizens can be made conditional on private sector behaviour, such as school attendance. Direct support can be offered to productive sectors, through agricultural extension or

industrial policy. And government can engage in domestic debt management, both by retiring public debt or by directly lending to the private sector through institutions such as development banks. Of course, the impact of each of these depends on the honesty and efficiency with which policies are implemented.

Results derived in this paper are obviously indicative rather than definitive, but they point to the considerations that have to be taken into account if resource revenues are to be managed effectively. Natural resources are now being discovered in new countries and commodity price increases will bring recurring booms. If countries are to make more of these opportunities than they have in the past then choices need to be informed by further research on revenue management. This is a fertile area of work that needs to be pursued, going beyond the analysis of this paper to investigate both the macro and the micro-economics of revenue management, using both analytical and empirical methods.

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