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Resource Windfalls, Optimal Public Investment, and Redistribution

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Abstract

This paper studies the optimal public investment decisions in countries experiencing a resource windfall. To do so, we use an augmented version of the Permanent Income framework with public investment faced with adjustment costs capturing the associated state capacity as well as government direct transfers. A key assumption is that those adjustment costs rise with the size of the resource windfall. The main results from the analytical model are threefold. First, a larger resource windfall commands a lower level of public capital but a higher level of redistribution through transfers. Second, weaker state capacity lowers the increase in optimal public capital following a resource windfall. Third, higher total factor productivity in the non-resource sector reduces the degree of des-investment in public capital commanded by weaker state capacity. We further extend our basic model to allow for "investing in investing" —that is public investment in state capacity— by endogenizing the adjustment cost in public investment. Results from the numerical simulations suggest, among other things, that a higher initial stock of public "know how" leads to a higher level of optimal public investment following a resource windfall. Implications for policy are discussed.

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Resource Windfalls, Optimal Public Investment and Redistribution

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1. Introduction

Countries dependent on natural resources face complex challenges. In the short run, fiscal and export revenues from resources are volatile and uncertain, and complicate the conduct of macroeconomic policy (see Frankel, 2012). In the long run, the main challenge is to rebalance national wealth. Development is strongly associated with a shift from natural capital to other forms of wealth – whereas natural capital represents over thirty percent of total national wealth for developing countries in Africa and the Middle East it accounts for less five percent for the most advanced economies (Figure 1). Relying solely on revenues derived from the exploitation of finite resources may not be a sustainable option; the non-resource sector eventually needs to sustain growth after the stock of natural capital is exhausted. [1] But does this mean that the governments of all resource-rich countries should simply use their revenues to boost public investment?

This paper considers optimal public investment decisions in countries experiencing a resource windfall, but with different institutional conditions. In this, we build on the substantial body of research on the role of institutions in shaping economic outcomes, including North (1990), Keefer and Knack (1995), Quinn and Wooley (2001), Acemoglu, Johnson, and Robinson (2001), and Besley and Persson (2009). We use an augmented version of the Permanent Income framework, embedding this into institutional assumptions on public capacity and the business climate faced by the private sector. We assume that government can use its resources for public investments or transfer them directly to citizens. Public investment faces adjustment costs due to limited state capacity and rent-seeking behavior and these costs are assumed to rise with the size of the resource windfall. In contrast, transfers can be made without deadweight cost, a reasonable assumption from recent experience using modern technology to identify citizens and pay them.

[1] The focus of the present paper is on resource windfalls stemming from revenues derived from the exploitation of non-renewable resources such as hydrocarbons and minerals. To the extent that they also generate appreciable levels of rent, for example from licenses, We thereafter refer to natural resources as resources of the non-renewable type. It should be noted however that the issues raised in this paper are also relevant for to countries dependent on the exploitation of renewable but limited resources such as agricultural products, fisheries and forestry. Indeed, the overexploitation of such a stock of a priori renewable resources may cause them to become effectively exhausted. A few countries with small populations and very large resource reserves may be able to thrive as “rentier states”, relying on the investment income from transforming their resources into financial capital. This paper is less applicable to them, although they also should be concerned about the nature and the quality of their investments

The main results from the analytical model are fourfold. First, the larger is the resource windfall the less of it should government invest and the more it should transfer to its citizens. Second, weaker state capacity reduces the optimal increase in public capital following a resource windfall in favor of larger transfers. Third, a less favorable business climate, proxied by lower total factor productivity in the non-resource sector, reduces the value of public capital and further increases the optimal level of transfers. We further extend our basic model to allow for "investing in investing" —that is public investment in state capacity to manage the investment program— by endogenizing the adjustment cost in public investment. "Investing in investing" is more valuable in the case where the country has a stronger business climate. This result shows the importance of making strong efforts to strengthen the business climate rather than simply relying on a public-investment-driven approach.

Public Investment Management Capacity. For an investment-led strategy to be effective, governments in resource rich countries need to be able to identify, implement and monitor key investments intended to provide the public goods necessary for the non-resource private sector to develop,[2] and to avoid wasting their limited resources. [3] However, as shown in Figure 2 state capacity in the area of public investment management is particularly weak in resource rich countries relative to others (Kyobe et al. (2011)). Case studies support this conclusion. Gelb (1988) documents the large investment projects made by oil exporting countries during the boom of the 1970s. They were plagued by inefficiencies and contributed to resource misallocation; in addition, those disproportionally large investment projects depreciated quickly and sometimes failed to provide services as governments were unable to cover high operations and maintenance costs. Over-extended resource rich countries have often fallen into debt overhang following commodity price booms. Arezki and Brückner (2010 a, b) show how booms have led to increased government spending, high external debt and elevated default risk marked by widened sovereign bond spreads, and that this risk is particular to countries with weak institutions. To avoid these pitfalls, the ability

[2] Governments in resource rich countries are heavily involved in the natural resource sector, through taxation, the sale of licenses to foreign companies, and sometime more directly through government owned companies. They dispose of a large share of the rents derived from the exploitation of natural resources.

[3] Warner (2012) shows that it is not necessarily optimal to address every externality or to always select expenditures with the highest social returns.

to manage public investment needs to be taken into account when determining the optimal use of a resource windfall.

Low quality public investment management in resource-rich countries is not simply a matter of inherent capacity. Resource rents offer scope for improving capacity, including through competitive pay for public officials, as in Botswana. The real underlying problem is the "rent-seeking" use of the investment program: resource revenues transiting through government coffers offer scope for discretion and capture by public officials. Using a panel of 30 oil-exporting countries during the period 1992–2005, Arezki and Bruckner (2011) show that an increase in oil rents causes a significant increase in corruption. Rent seeking is thus more likely to render public expenditures ineffective, including those intended to spur industrialization.

The business environment and TFP. The second factor affecting optimal spending in resource rich countries is the quality of the business environment faced by firms, including the rule of law and regulations that impact on firms' investment decisions. Weak rule of law increases the risk of expropriation and diverts both foreign and domestic investment (Alfaro et al., 2008). Incentive incompatible regulations may also trigger rent seeking which, in turn, deters the private sector response to public infrastructure. Figure 3 shows that Sub-Saharan Africa and Middle East and North Africa, regions with many resource rich countries, provide a poor level of investor protection as measured by the World Bank (2011). Using panel data for over a hundred countries, Arezki et al. (2011) provide evidence that the quality of economic institutions has played a crucial role in enabling government expenditure to boost non-resource sector growth in commodity exporting countries over the period 1970 to 2007. As shown by Hall and Jones (1999), the quality of institutional arrangements for limiting expropriation risk has a statistically significant and economically large impact on cross-country total factor productivity (TFP) differences. The level of TFP can then be used as a summary measure of the quality of the economic institutions faced by private firms. In the case of resource rich countries, we are specifically interested in the level of TFP in the non-resource sectors as a measure of economic conditions faced by firms operating in those sectors. Figure 4 shows this for different regions; Africa has the lowest level of non-resource sector TFP. [4]

Which Institutions Matter? While there is evidence of a causal relationship between good institutions and economic development, we know little about which specific institution is fundamental in this process, in part because measures of institutions are quite highly correlated. Among the recent attempts to "unbundle" institutions is Acemoglu and Johnson (2005), who examine the effects of broad property rights and narrow contracting institutions. They find that only the latter are important in determining economic outcomes. In the present paper, we distinguish public state capacity from the economic institutions that affect non-resource TFP. As shown in Figure 5 the correlation between non-resource sector TFP and the public investment management index is positive but low, indicating that they have substantially different informational content.

As an example of these combined effects, industrial policies in resource rich countries in the Middle East and North Africa have failed to yield economic diversification. This is only partly because of weak investment administration; there is also an effect through the business climate. In a range of countries, including Algeria, policies and incentives have been captured by entrenched elites rather than used to attract new dynamic investors to boost productivity (Hausman et al (2010), Arezki and Nabli (2012)). Optimal spending following a resource windfall needs to take into account the effect of rents in reducing the effectiveness of public spending through both channels.

Citizen Dividends. Another possible use of resource revenues is to transfer them to citizens. Sala-i-Martin and Subramanian (2003) and Birdsall and Subramanian (2004) have made the case for such direct redistribution to citizen to fight the "resource curse" in the case of Nigeria and Iraq; an extensive literature argues for citizen dividends to help deliver visible benefits, create public demand for accountability, and strengthen the social contract (see Moss, 2011). Some resource-rich governments have initiated direct transfers, notably the State of Alaska and most recently Iran.[5] More generally, cash transfers have emerged as one of the most thoroughly researched forms of development interventions and one of the most effective. Many studies,

[4] In computing Figure 4, we have attempted to reduce the noise created by resource extraction when computing standard measure of TFP by purging resources from output.

[5] The dividend received by each Alaskan resident amounted about $1,300 in 2009 (Ross, 2012).

surveyed in DFID 2011and Garcia and Moore 2012, document their role in enabling households to reduce poverty and improve children's growth indicators and also to invest in human capital by enabling school attendance and access to health services. There is little evidence that transfers to poor people inhibit labor market participation; any effects in increasing demand for leisure appear to be offset by their impact in covering job search costs. In fact, they appear to encourage productive activity by lessening the failures in credit and insurance markets that constrain poor households. Small but reliable flows of transfers have helped poor households to accumulate productive assets, to avoid distress sales, to obtain access to credit on better terms and to diversify into higher risk and return activities. There is also some evidence that the introduction of transfers into poor remote areas can stimulate demand and local market development.[6]

New technology has also opened up new possibilities for the implementation of transfer programs at low cost, even in countries with low capacity.[7] Cellular phones and biometric smartcards are increasingly being used to deliver them, even in countries with poor institutions and low capacity. Biometric identification technology can overcome traditional difficulties in identifying recipients, preventing multiple payments and eliminating "ghosts". Gelb and Decker (2012) consider 19 programs; while not all have been comprehensively evaluated, the evidence indicates that transfers can be implemented with little leakage and on a large scale, and by using identification and payment technologies that provide benefits beyond the transfer program itself, including widened financial access. These technologies are particularly suited to distributing a uniform "oil dividend" across the population, since this avoids the costs that would otherwise be involved in income-based or other targeting. [8] As a first approximation, it is therefore reasonable to assume that policymakers have the option of using part of a resource windfall for providing direct transfers at zero transfer cost.

[6] Studies of the impact of remittance income have also documented their effect in reducing poverty and encouraging investment, in health, education and housing (Adams 2005, Clemens 2011).

[7] Yet technology will not eliminate the cost associated with distribution of cash transfers even so it can reduce it.

[8] Pakistan's Watan smartcard offers an example of large-scale cash distribution, in that case to assist with reconstruction after disastrous flooding. An assessment found that over 1.5 million households had received the grant with minimal leakage or diversion, and with very low travel costs. The program drew on Pakistan's national biometric database (Hunt et al 2011).

The remainder of the paper is organized as follows. Section 2 briefly discusses existing theoretical frameworks used in the literature on optimal public spending. Section 3 outlines the setup of our basic model. Section 4 presents an extension of the model. Section 5 discusses policy implications.

2. Existing Theoretical Frameworks

The Permanent Income (PI) framework is widely used to help inform policy makers identify the appropriate level of spending given a transitory increase in resource revenues (see Ossowski and Barnett, 2002). It derives the level of (non-interest) spending that maximizes the lifetime utility of an infinite horizon agent in an economy endowed with an exhaustible stock of natural resources:

$$\underset{\{G\}_{t=1}^{\infty}}{Max}\sum_{t=1}^{\infty}\beta^{t-1}U(G_t)$$

$$st B_t = RB_{t-1} + G_t - T_t - Z_t \qquad (1)$$

$$\underset{s\to\infty}{Lim}\, B_{t+s} = 0 \qquad (2)$$

where G is (non interest) government spending, B is the level of indebtedness, T is non-resource revenue, Z is resource revenue, N is the number of years the stock of natural resource reserve will last, β is the discount factor, r is the interest rate and R is defined as: $R=1+r$. We further assume $\beta R=1$. Equation (1) is simply the resource constraint, and equation (2) is the standard transversal condition.

The solution derived from the maximization is straightforward:

$$\overline{G} = T + \frac{r}{R}\sum_{j=0}^{N-1}R^{-i}Z - rB_{t_0}$$

Where $\overline{G}$ is the optimal level of government spending. The middle term is the flow of interest revenues that would be earned on the present discounted value of the future resource revenue streams derived from the exploitation of natural resources. Government effectively consumes the annuity derived from the permanent income on total wealth derived from recurrent income sources and the exploitation of exhaustible resources. Hausmann, Powell, and Rigobon (1993) describe the PI solution as: “The government behaves as if it sold all of its oil immediately, thus effectively transforming the flow of oil revenue into a stock of financial assets." Figure 6 shows the evolution of financial assets over time for such a solution. Government accumulates assets until it reaches its target level. Consumption in this specific case is flat.

The simple PI framework is subject to a number of important caveats, and researchers have attempted to enrich it by introducing more realistic assumptions. Most notably, Collier, Venables, van der Ploeg and Spence (2011) and Venables and van der Ploeg (2011) augment the PI framework. They assume that individuals face borrowing constraints and that the economy faces an interest premium on foreign debt. The economy also faces capital scarcity -- the marginal product of capital at home is higher than in the rest of world. Results derived from the modified optimizations yield three main lessons. First, a government attempting to smooth individuals' consumption and facing borrowing constraints should use windfalls to increase individuals' consumption through dividends financed first through borrowing and then through interest on savings out of resource windfalls. Second, heavily indebted countries facing premiums on foreign borrowings should consider using their resource windfalls to repay their foreign debt rather than accumulating assets with typically lower returns. Third, low-income countries facing capital scarcity should favor public investment, including infrastructure to help encourage domestic investment, over saving in foreign financial assets yielding lower returns.

These analyses have expanded the frontier of knowledge on optimal spending decisions in resource-exporting countries. However, there is still the question of which variants of the enriched PI model are most relevant for particular countries, and this brings in the nature of their capacity limitations and their economic institutions.[9] We now introduce a simple framework to integrate these important features.

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[9] Berg et al. (2011) and Van der Ploeg (2012) explore how absorptive capacity constraints shape the macroeconomic effects of natural resource oil windfalls in developing countries, including those associated with public investment. They, however, do not investigate specifically at the interaction between state capacity and economic institutions. Also, the theoretical framework presented in our paper is tractable enough to allow us to derive closed form solutions.

3. A Simple Model

3.1. Model Set-Up

We consider a small open economy that can borrow or lend unlimited amounts at world interest rate r^*. The government has access to international capital markets; let F be the level of sovereign debt. The economy is composed of two sectors namely the resource sector and the non-resource sector. At time $t = 0$, the government anticipates a windfall N_t between period $t = t_0$ and $t = t_N$ originating from the natural resource sector.[10] Non-resource domestic income is given by $Y = AH(K, S)$ where A is the total factor productivity of the non-resource sector capturing the economic conditions faced by the latter. K is the stock of private capital and S the stock of public capital.[11] We do not impose a particular functional form for the function H but derive our results assuming that this function is homogenous of degree one, which means that we can re-write

$$Y = AH\left(\frac{K}{S}, 1\right)S = Ah\left(\frac{K}{S}\right)S.$$

This assumption is general enough to allow for different values of the elasticity of substitution between private and public capital stock; it nests the Constant Elasticity of Substitution (CES) production function, a special case of which is the Cobb-Douglas form.

Public capital is owned by the government and depreciates at rate δ_S and private capital depreciates at rate δ_K and is rented from foreign owners who face a world interest rate r^*. The government can invest in public capital but faces adjustment costs $g(I_t) \geq 0$.[12] If the government plans to increase the stock of public capital by I_t units, it needs to spend $I_t + g(I_t)$. Adjustment costs are assumed to rise with the net present value of the resource windfall, as larger windfalls offer more scope for rent-seeking behavior by

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[10] In this paper, we assume no uncertainty regarding the resource revenue. Collier et al (2011) address the issue of volatility, and the need for savings to cushion shocks.

[11] We assume regularity of the production function H, i.e. $H_X > 0, H_{XX} < 0 \; for \; X = K, S$.

[12] Note that the results presented in this section hold for any functional form $g(I)$satisfying $g() \geq 0$.

public officials: $V = \sum_{t=0}^{T}(1+r^*)^{-t}N_t$.[13] For notational simplicity, we keep this relation implicit in the functional form of $g(I_t)$. The adjustment cost is aimed at capturing the cost of corruption resulting from officials' demand for special payments and the extent of illegal payments throughout tiers of government (see Political Risk Services, 2009).[14]

Households have no access to foreign markets to smooth consumption but the government can distribute transfers to their citizens as resource dividends without additional deadweight costs.[15] Current consumption C_t is given by $C_t = W_t + G_t$ where W_t is the current wage and G_t is the transfer.

Profit maximizing firms will set the marginal productivity of private capital equal to its marginal cost:

$$Ah_K\left(\frac{K}{S}\right) = r^* + \delta_K.$$

Under the regularity conditions imposed on the production function this equation yields an implicit function of the stock of private capital on the current stock of public capital $K_t = K(S_t, A_t)$. Given our regularity conditions, the inverse function h_K^{-1} exists such that we obtain: $K = h_K^{-1}\left(\frac{r^*+\delta_K}{A}\right)S$. The optimal stock of private capital is linear in S.

Since wages are by definition given as $W_t = Y_t - (r^* + \delta_K)K_t$, current wages are given by an implicit function of the current stock of public capital:

13 It is important to note that the specification chosen is general enough to accommodate various situations but we focus here on the case where those adjustment costs depend on the net present value of the resource windfall. In section 4, we consider the case where adjustment costs depend on the stock of public know-how.

14 We abstract here from modeling specifically the potential welfare loss resulting from misallocation of resources and the costs associated with secrecy.

15 While technology can help reduce the cost of distributing cash transfers but will not eliminate it. Here we assume no additional deadweight costs for simplicity. The assumption allows us to capture the relative differences in costs between distributing cash transfers and public investment without loss of generality.

$$W_t = W(S_t, A_t) = \left(Ah\left(h_K^{-1}\left(\frac{r^*+\delta_K}{A}\right)\right) - (r^* + \delta_K)h_K^{-1}\left(\frac{r^*+\delta_K}{A}\right)\right)S.$$

We note that:

$$W_S = Ah\left(h_K^{-1}\left(\frac{r^*+\delta_K}{A}\right)\right) - (r^* + \delta_K)h_K^{-1}\left(\frac{r^*+\delta_K}{A}\right) = \frac{Y-(r^*+\delta_K)K}{S} > 0,$$

is constant. We therefore have $W_S(S, A) = W_S(A)$.

Differentiating with respect to A yields the cross-partial:

$$W_{SA} = h\left(h_K^{-1}\left(\frac{r^*+\delta_K}{A}\right)\right) > 0.$$

Wages are therefore increasing with the stock of public capital, and even more so when non-resource sector TFP is higher.

The government's problem is to choose investment in public capital I_t and transfers G_t so as to maximize the utility of its citizens:

$$Max_{\{I_t, G_t\}} \sum_{t=0}^{\infty} \beta^t U(C_t)$$

while facing the following constraints:

$$F_{t+1} = (1 + r^*)F_t + G_t + I_t + g(I_t) - N_t$$

$$S_{t+1} = (1 - \delta_S)S_t + I_t$$

$$C_t = W(S_t, A_t) + G_t$$

$$\lim_{t\to\infty} F_t = 0$$

$$F_0 = F.$$

The associated Bellman equation reads as follows:

$$V(F_t, S_t) = Max_{\{I_t, G_t\}}\{U(C_t) + \beta V(F_{t+1}, S_{t+1})\}$$

Combining the first order and envelope conditions for this problem yields the following Euler equations:

$U_{C_t} = \beta(1 + r^*)U_{C_{t+1}}$ (1)

$g_I(I_t) = \frac{r^*+\delta_S-W_{S_t}}{1-\delta_S} + \frac{1+r^*}{1-\delta_S} g_I(I_{t-1})$ (2)

Equation (1) indicates that it is optimal to smooth consumption over time, i.e. $C_t = C_{t+1} = C$ if $\beta(1 + r^*) = 1$. This optimal level of consumption is obtained from the boundary condition imposed on the sovereign debt. Equation (2) gives the dynamic optimal path of investment in public capital, linking investments at *t* to investments at *t-1*.[16] The steady state is as follows:

$g_I(I^*) = \frac{W_S(A)}{r^*+\delta_S} - 1$ (3)

Note that as long as the world interest rate is lower than the marginal benefit (costs) of the stock of public capital net of depreciation, that is $r^* < W_{S_t} - \delta_S$, there exists a solution for I^*.

Equation (3) indicates that countries with a higher TFP will have a higher steady state investment in public capital as long as g_{II}>0.[17] Also, consider two economies, say

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[16] One should note that this difference equation represents an upward sloping line with slope $\frac{1+r^*}{1-\delta_S} \geq 1$, in the $(g_I(I_{t-1}), g_I(I_t))$ plan. This means that the dynamic process does not converge towards the steady state, i.e. if $g_I(I_{t-1}) < g_I(I^*)$ then $g_I(I_t) < g_I(I_{t-1})$ and vice versa. Stated otherwise, we have $g_I(I_t) = c + bg_I(I_{t-1})$ and replacing successively $g_I(I_{t-1})$ by its expression using this equation we arrive at: $g_I(I_t) = c\frac{1-b^t}{1-b} + b^t g_I(I_0)$. Clearly, the steady state is given by $c\frac{1}{1-b}$. As t becomes large, we would converge to the steady state if and only if b is lower than 1. In our case, $= \frac{1+r^*}{1-\delta_S} \geq 1$.

[17] Let $I^*(A)$ be the implicit solution of equation (3). Plugging this expression and differentiating (3) with respect to A yields: $g_{II}I_A^* = \frac{W_{SA}}{r^*+\delta_S} > 0$. For $g_{II} \geq 0$, this means that $I_A^* > 0$.

k and l, with $g_I^l(\quad) > g_I^k(\quad)$ such that economy l faces higher marginal adjustment costs, but otherwise similar. Public capital investment in steady state will be lower in economy l than in economy k since the right-hand side of (3) is the same for both economies and $g_{II} > 0$. This means that the larger the marginal investment costs (i.e., possibly because of a higher windfall), the lower the steady state investment in public capital. All else equal, the steady state stock of public capital, $S^* = \frac{I^*}{\delta_S}$, and therefore of private capital, is thus larger in economies with higher levels of TFP or with smaller adjustment costs.

For illustrative purposes we consider numerical simulations of the model when H takes a Cobb-Douglas functional form $K^\gamma S^{1-\gamma}$ where $0 < \gamma < 1$. The parameters are set out in Appendix 1. Figure 7 shows the evolution of the level of debt under a temporary resource windfall for our benchmark calibration. The government first accumulates debt anticipating the resource windfalls, and then accumulates assets. The level of consumption appears relatively flat, which is not surprising since the objective of the maximization program is to smooth it, as the sum of wages plus the government transfer. We next discuss the results of simulations under various parameter values for the adjustment cost and the TFP.[18]

3.2. Discussion of Results

We first let two economies start from a similar steady state except for the respective sizes of their resource windfalls at time, t0. This experiment allows us to compare the differences between economies in the evolution towards steady state spending on public capital. A larger resource windfall commands a lower level of public capital (Figure 8). This can be explained by the fact that the larger windfall imposes higher adjustment costs, which render a high level of public investment suboptimal relative to redistribution through direct government transfers. Indeed, Figures 9 and 10 show that while the level

[18] Note that for our benchmark calibration, we choose:

$I_0 = I^*, S_0 = 0.75 \times S^*, F_0 = 5, N = 10, \delta_S = 0{,}05, \delta_K = 0{,}05, r^* = 0{,}08, A = 0{,}29, \gamma = 0{,}56\ and\ \bar{\alpha} = 0{,}1 + 0.005 \times V$. We increased A by 0.075 for "high TFP" scenarios and the constant in $\bar{\alpha}$ by 0.7 "high adjustment costs" scenarios.

of wages is lower, the level of consumption is higher in the economy with a larger windfall compared to the economy with lower one.

We now consider the implications of different institutional conditions, involving different levels of state capacity and TFP. Four main results emerge. First, weaker state capacity lowers the level of optimal public capital. When adjustment costs are higher, optimal public investment is reduced and less private capital is rented, as shown in Figures 11 and 12. Wages are thus lower, and consumption is lower as shown in Figures 13. Governments aiming to maximize, and smooth individuals' consumption will internalize the prohibitive level of adjustment costs and relinquish the option to invest a large amount in public capital.

Second, a more productive private sector, as measured by higher TFP, increases the optimal level of public capital as shown in Figures 11 and 12, because each increment can crowd in more private capital. There is little point in making public investments if private investment is severely constrained by other factors, such as the insecurity of property rights. Given our choice of functional form and parameters, the share of wages is lower as a larger share of output goes to the (private) rental of capital. To compensate, it is optimal for the government to increase transfers, as shown in Figure 13.

Third, better economic conditions for the business sector increase the sensitivity of optimal public investment to the level of state capacity. The gap in optimal public investment between economies with high and low adjustment costs is larger when the level of TFP is higher, as shown in Figure 11. There is less payoff to public investment, whether effective or not, when private productivity is heavily constrained by other factors.

Finally, even though it is optimal to transfer more to households when low TFP and high adjustment costs constrain optimal public investment in favor of transfers, private consumption is lower in this case (Figure 13). Direct distribution cannot completely compensate for poor capacity and institutions.

4. An Extension of the Model with Endogenous Investment in State Capacity

So far, we have assumed that public investment adjustment costs are exogenously determined. In the following, we describe a simple way to make them endogenous. Let T_t be the stock of "know-how" in administering public investment projects. Assume that this stock can be increased through investments J_t as follows:

$T_{t+1} = T_t + J_t$.

Let adjustment costs in public capital investment be given by the function $g(I_t, T_t)$ with $g_I > 0$ and $g_T < 0$ such that past investments aimed at building state capacity (captured in the current stock of T_t) decrease adjustment costs. [19]

The government now chooses both investment in state capacity and investment in public capital and faces the additional accumulation constraint. The problem is now to choose transfers G_t, investment in public capital I_t and investment in state capacity J_t so as to maximize the utility of citizens:

$$Max_{\{I_t, J_t, G_t\}} \sum_{t=0}^{\infty} \beta^t U(C_t)$$

While facing the following constraints:

$F_{t+1} = (1 + r^*)F_t + G_t + I_t + g(I_t, T_t) + J_t - N_t$

$S_{t+1} = (1 - \delta_S)S_t + I_t$

$T_{t+1} = T_t + J_t$

$\lim_{t \to \infty} F_t = 0$

$F_0 = F$.

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[19] We use the specification $g(I_t, T_t) = \frac{1}{2}\bar{\alpha}(T_t)(I_t - \tilde{I})^2$ in our numerical examples.

This yields a third Euler condition as follows:

$-g_{T_t} = r^*$ (4)

Under regularity conditions imposed on the function g, this third Euler condition allows us to write investment in public capital at time *t* as an implicit function, say $q(T_t)$, of the stock of know-how in public administration at time *t* as:

$I_t = q(T_t)$ (5)

A simple comparative static exercise shows that public investment will increase with the stock of know-how if and only if $-\frac{g_{TT}}{g_{TI}} > 0$.[20] It seems reasonable to assume that $g_{TT} > 0$, $g_{IT} < 0$ and $g_{II} > 0$. In this case, the condition is satisfied and the steady state investment in public capital investment increases with the stock of know-how in public administration. This result augments those obtained from the basic model, as they suggest that countries faced with resource windfalls should progressively adjust their optimal level of investment in public capital to their stock of know-how in the public administration.

Moreover, replacing I_t by $q(T_t)$ as derived from the third Euler condition, we can re-write the second Euler equation to arrive at:

$\Delta(T_t) = \frac{r^*+\delta_S-W_{S_t}}{1-\delta_S} + \frac{1+r^*}{1-\delta_S}\Delta(T_{t-1})$ (6)

where $\Delta(T_t) = g_I(q(T_t), T_t)q(T_t)$ and with $\Delta_T(T_t) = \left(g_{IT} - g_{II}\frac{g_{TT}}{g_{TI}}\right)q - g_I\frac{g_{TT}}{g_{TI}}$.

Note that the sign of $\Delta_T(T_t)$ clearly depends in a non-trivial fashion on the shape (the curvature of function $g(.)$ in T and I and the degree substitution between T and I in function $g(.)$) of the adjustment cost function. However, we note that a sufficient, though not necessary, condition for $\Delta_T(T_t) > 0$ is $g_{IT} - g_{II}\frac{g_{TT}}{g_{TI}} > 0$ since $q > 0$ and

[20] $\frac{\partial I_t}{\partial T_t} = q_T(T_t) = -\frac{g_{TT}}{g_{TI}}$ provided $g_{TI} \neq 0$.

$-g_I \frac{g_{TT}}{g_{TI}} > 0$ when $g_{TT} > 0$, $g_{IT} < 0$ and $g_{II} > 0$.

This sufficient condition rewrites as $g_{IT}^2 < g_{II} g_{TT}$.

The steady state of the stock of know-how is as follows:

$\Delta(T^*) = \frac{W_S(A)}{r^*+\delta_S} - 1$ (7)

This equation yields an implicit function of the steady state stock of know-how $T^*(A)$. Plugging this into (7) and differentiating with respect to A yields:

$$\Delta_T T_A^* = \frac{W_{SA}}{r^* + \delta_S} > 0$$

The steady state stock of know-how should increase with the quality of economic institutions, if and only if $\Delta_T > 0$. Without further assumption on the shape of adjustment costs, it is however impossible to ascertain that the sign of this derivative is positive. However, if $g_{TT} > 0$, $g_{IT} < 0$ and $g_{II} > 0$ and $g_{IT}^2 < g_{II} g_{TT}$ then $\Delta_T > 0$ and $T_A^* > 0$, this derivative is positive. Under those assumptions, it is therefore optimal to invest in building the stock of know-how in public administrations especially in a context of higher level of TFP.

5. Conclusion and Policy Implications

The paper has studied the optimal public investment decision in countries experiencing a resource windfall. Our results suggest that it is not necessarily the case that governments in resource rich countries should focus only on investment in the context of windfalls. Spending on public capital is not the only option especially in a context of weak state capacity. Certainly, small transient windfalls might be best invested. But under the realistic assumption that rent-seeking behavior reduces the effectiveness of public investment management in response to a larger resource windfall, it should command a lower emphasis on increasing public capital and a higher level of redistribution through direct transfers. Country context is also important. Weaker state capacity reduces the optimal increase in public capital following a resource windfall. So does lower a weaker business climate, represented by total factor productivity in the non-resource sector, which reduces the payoff to public capital.

In the medium run, investment in relaxing both of those constraints is an urgent priority if natural resource rents are to realize their full developmental benefits. The option of citizen dividend transfers with no deadweight costs provides a useful alternative but cannot offset the negative effects of these constraints. That said, state capacity may be relatively more malleable than non-resource sector total factor productivity, and we thus extended our basic model to allow for "investing in investing" —that is public investment in state capacity. A higher initial stock of public "know how" leads to a higher level of optimal public investment following a resource windfall, but the effect can still be constrained by a poor investment climate.

Investment in state capacity in resource rich countries could take place through increasing transparency in the handling of resource windfalls and better identifying and implementing projects. There exist important international initiatives aimed at enhancing transparency in the management of natural resources revenues as well as at enhancing the effectiveness with which those revenues are spent. The Extractive Industries Transparency Initiative (EITI) constitutes a set of global standards for transparency in the oil, gas and mining extractive industries, and the Natural Resource Charter, which builds on EITI, represents a more comprehensive set of principles for governments and societies on how to best harness the opportunities created by extractive resources for development. More specifically, open publication of public procurement contracts can help to improve investment quality and reduce contract costs and cost overruns (Kenny and Karver 2012). These initiatives should serve as anchors for enhancing transparency and accountability in resource rich countries and reducing misappropriation and overruns costs in public investment programs.

Some lessons can also be learned from Chile's three decades of experience in subjecting all public projects to disciplined and transparent cost-benefit analysis (see Ley, 2006). The National System of Investments (SNI) was established at the Ministry of Planning (MoP), currently administered jointly with the Ministry of Finance (MoF). All public-investment projects are appraised by MoP on the basis of cost-benefit analyses carried out with a clearly specified methodology—including a shadow social price system and a social rate of discount—and by project appraisal units institutionally separate from project development units. The World Bank has long supported Project Implementation Units (PIU), stand-alone entities to assist in the implementation of World Bank-financed projects. The record with project-specific PIUs is however mixed, including because of the lack of continuity and accumulation of know- how in state capacity. The Bank has been recommending that PIUs be integrated into line ministries so diffuse knowledge, but there is still the issue of accountability. These experiences are useful and telling, but there is a need for both more empirical work in documenting cross- and within country differences in state capacity and more academic work on the political economy of building it, particularly in the context of high natural rents.

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Appendix 1: Parametric Specification

Let $U(C) = \frac{C^{1-1/\sigma}}{1-1/\sigma}$ with $\sigma < 1$ such that $U_C = C^{-1/\sigma}$ and let $g(I) = \frac{\bar{\alpha}}{2}(I - \tilde{I})^2$ where $\bar{\alpha} \geq 0$. Let the production function be of a Cobb-Douglas form with constant returns to scale, i.e. let $\mathrm{H}(K, S) = K^{\gamma} S^{1-\gamma}$ where $0 < \gamma < 1$.

We have:

$K(S, A) = aA^{\frac{1}{1-\gamma}}S$, where $a = \left(\frac{\gamma}{r^* + \delta_K}\right)^{\frac{1}{1-\gamma}}$

$C = W(S, A) = a^{\gamma} A^{\frac{1}{1-\gamma}}(1 - \gamma)S$

$W_S = a^{\gamma} A^{\frac{1}{1-\gamma}}(1 - \gamma) = \overline{W}_S$

$g_I = \bar{\alpha}(I - \tilde{I})$.

The Euler equation now reads as:

$$\bar{\alpha} I_t = \frac{r^* + \delta_S - W_{S_t}}{1 - \delta_S} + \frac{1 + r^*}{1 - \delta_S} \bar{\alpha} I_{t-1} - \bar{\alpha} \frac{\delta_S + r^*}{1 - \delta_S} \tilde{I}$$

When $\bar{\alpha} > 0$, we obtain:

$$I_t = \frac{1}{\bar{\alpha}} \frac{r^* + \delta_S - W_{S_t}}{1 - \delta_S} + \frac{1 + r^*}{1 - \delta_S} I_{t-1} - \frac{\delta_S + r^*}{1 - \delta_S} \tilde{I}$$

We further write $\bar{\alpha} = \alpha + \delta V$ with $\alpha > 0$ and $\delta \geq 0$ to take into account the potential link between the windfall size and adjustment costs.

Appendix 2: Parametric Specification of the Extended Model

Let $g(I, T) = \bar{\alpha}(T) \frac{(I - \tilde{I})^2}{2}$ where $\bar{\alpha}(T_t)$ is modeled as follows:

$\bar{\alpha}(T_t) = \frac{1}{n}(1 + e^{T_t})^{-n}$, with $n > 0$. As T_t tends to ∞, the adjustment costs tend to 0. The parameter n governs the speed with which this convergence process occurs. The larger n the faster it converges to 0.

Given this specification, the third Euler condition can be rearranged to obtain: $I_t = (2r^*)^{1/2}(1+e^{T_t})^{\frac{n+1}{2}} + \tilde{I}$, which yields: $\frac{\partial I_t}{\partial T_t} = \frac{n+1}{2}(2r^*)^{1/2}(1+e^{T_t})^{\frac{n-1}{2}} > 0$.

The second Euler condition yields:

$\Delta(T_t) = \frac{(2r^*)^{1/2}}{n}(1+e^{T_t})^{\frac{1-n}{2}}$ for all t.

We therefore obtain:

$$\frac{\partial \Delta(T_t)}{\partial T_t} = \frac{1-n}{2}\frac{(2r^*)^{1/2}}{n}(1+e^{T_t})^{-\frac{1+n}{2}}$$

Since $\Delta(T_t)$ increases over time as indicated by the second Euler condition when $r^* + \delta_S - W_{S_t} > 0$, this means that when $n > 1$ the stock of know-how decreases over time and so does investment in public capital. However, when $0 < n < 1$, the stock of know-how increases over time and so does investment in public capital.

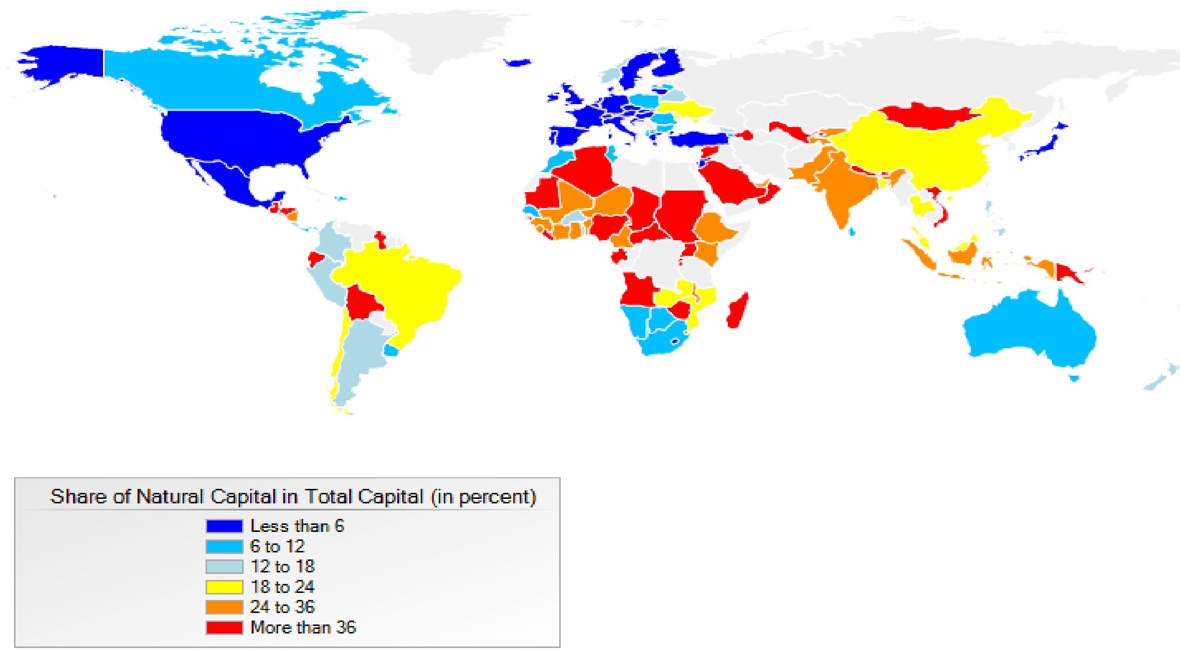
It follows that: $\Delta_t = \sum_{s=0}^{t-1}\left(\frac{1+r^*}{1-\delta_S}\right)^s \frac{r^*+\delta_S-W_{S_{t-s}}}{1-\delta_S} + \frac{1+r^*}{1-\delta_S}\Delta_0$.

The comparative statics now read as:

$\frac{\partial \Delta(T_t)}{\partial A} = -\sum_{s=0}^{t-1}\left(\frac{1+r^*}{1-\delta_S}\right)^s \frac{1}{1-\delta_S}\frac{\partial W_{S_{t-s}}}{\partial A} < 0$ since $\frac{\partial W_{S_{t-s}}}{\partial A} > 0$ for all $t-1 \geq s \geq 0$.

$\frac{\partial \Delta(T_t)}{\partial \Delta(T_0)} = \frac{1+r^*}{1-\delta_S} > 0$.

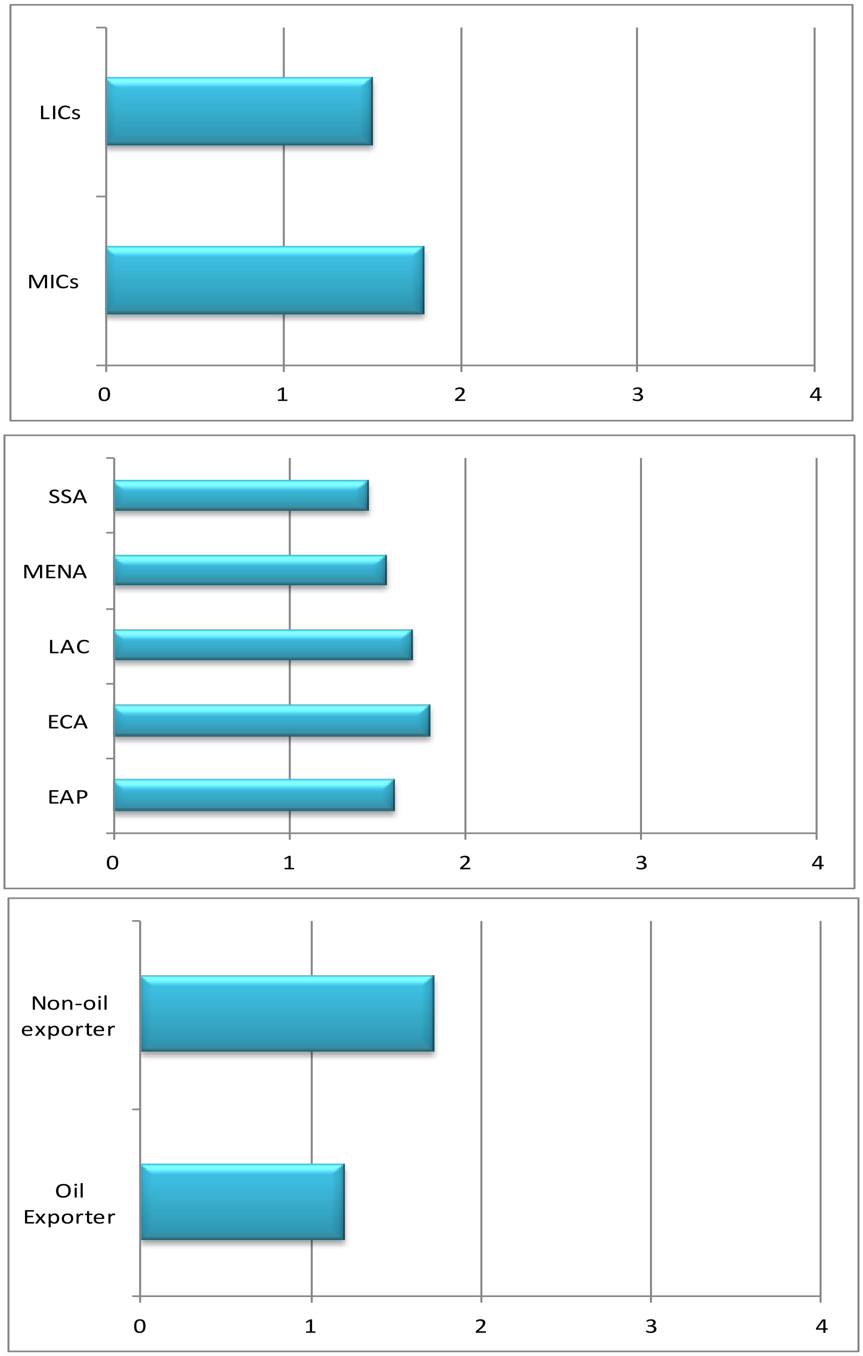
Figure 1. Share of Natural Capital around the World



Source: World Bank (2008).

Note: The share of natural capital is defined as the ratio of natural capital over total wealth. Natural capital is sum of Crop, Pasture Land, Timber, Non Timber Forest, Protected Areas, Oil, Natural Gas, Coal, and Minerals. Total wealth is sum of net foreign assets, produced capital, natural capital and intangible capital. Total wealth is calculated as the present value of future consumption that is sustainable, discounted at a rate of time preference of 1.5 percent, over 25 years. Intangible capital is obtained as the residual of total wealth minus net foreign assets, natural capital, and produced capital.

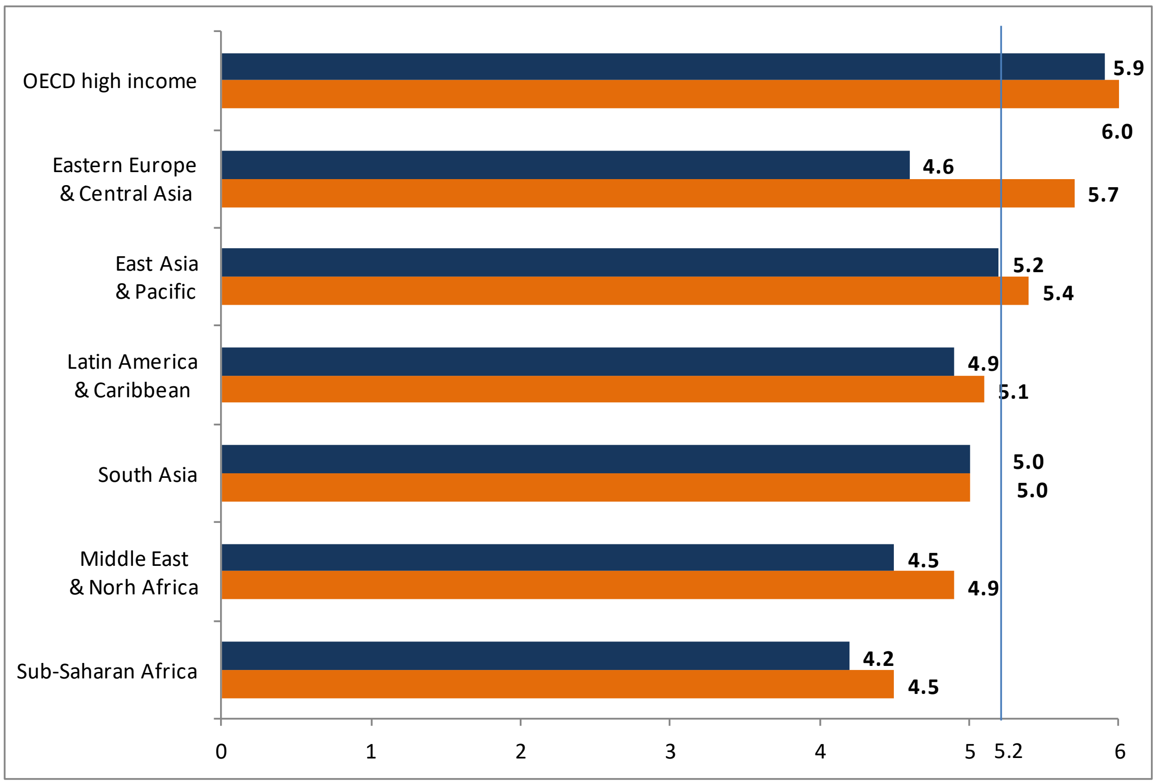
Figure 2. Public Management Index by Sub-Groups



Source: Kyobe, Brumby, Papageorgiou, Mills and Dabla-Norris (2011).

Note: The Public Investment Management Index (PIMI) overall index is derived as a simple average of the four sub-indices namely: (i) Strategic Guidance and Project Appraisal; (ii) Project Selection; (iii) Project Implementation; and (iv) Project Evaluation and Audit. The PIMI overall index aims to systematize available information regarding the functioning of identified stages of the public investment cycle. LICs: low-income countries; MICs: middle-income countries; SSA: Sub-Saharan Africa; MENA: Middle East and North Africa; LAC: Latin America and the Caribbean; ECA: Europe and Central Asia; EAP: East Asia and Pacific.

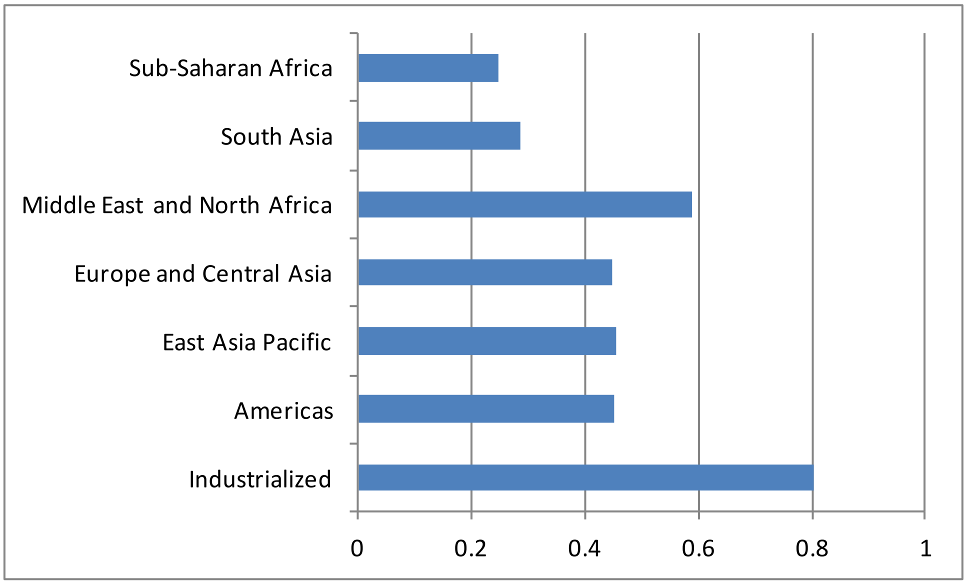
Figure 3. Investor Protection Index



Source: *Doing Business* database (DB).

Note: The data sample for DB 2006 (2005) includes 174 economies. The sample for DB2012 (2011) also includes The Bahamas, Barhain, Brunei Darussalam, Cyprus, Kosovo, Liberia, Luxembourg, Montenegro and Qatar, for a total of 183 economies. DB2006 data are adjusted for any data revisions and changes in methodology and regional classifications of economies.

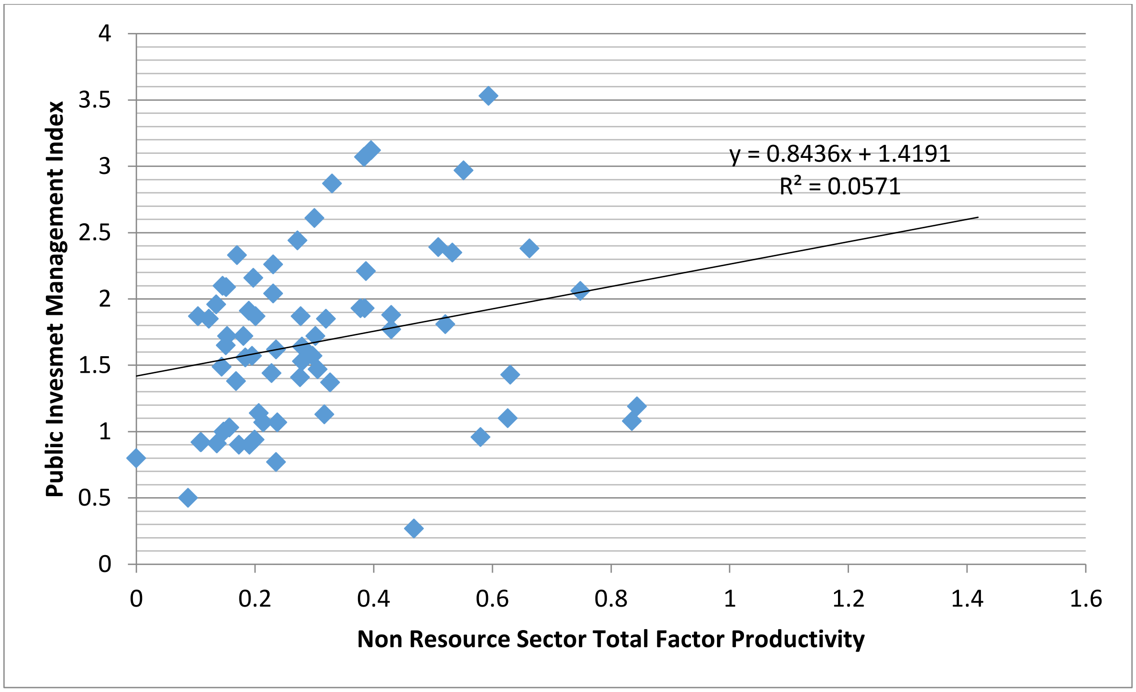
Figure 4. Non-Resource Sector Total Factor Productivity



Sources: Heston, Summers and Aten (2006), World Bank (2011b) and authors' own calculations.

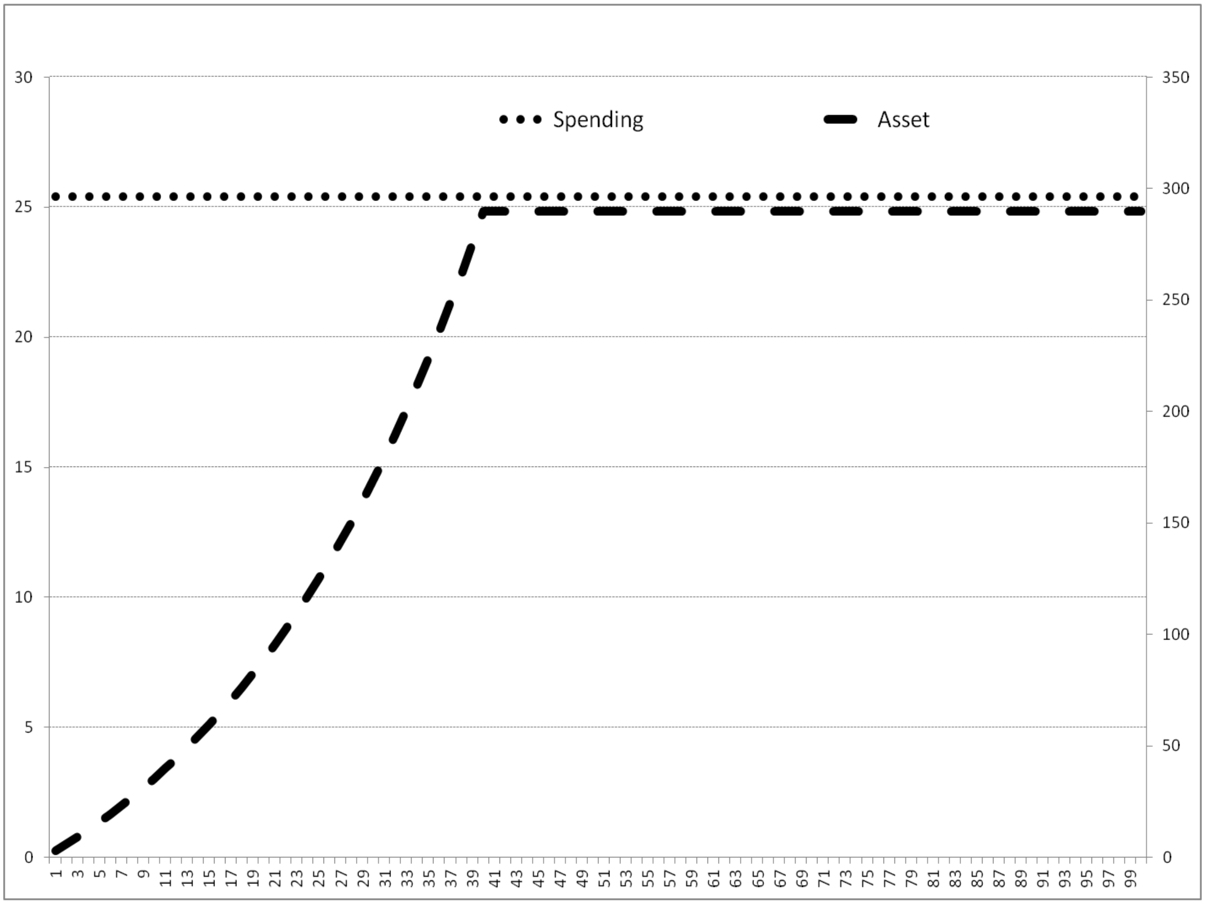
Note: Non-resource GDP is approximated by subtracting the real values of natural resources rents (obtained from World Bank, 2011b) from total GDP per worker in 2000 PPP adjusted USD (obtained from Heston, Summers and Aten, 2006). For each type of resource and each country, unit resource rents are thereby derived by taking the difference between world prices (to reflect the social opportunity cost of resource extraction) and the average unit extraction or harvest costs (including a "normal" return on capital). Unit rents are then multiplied by the physical quantity extracted or harvested to arrive at total rent. The energy resources include oil, natural gas and coal, while metals and minerals include bauxite, copper, gold, iron ore, lead, nickel, phosphate, silver, tin, and zinc. To back out non resource sector TFP by dividing non resource output by the stock of reproducible capital (derived from perpetual inventory method) at the power the factor share. The factor share is set at 0.34 as is standard in the literature. Capital investment is obtained from Heston, Summers and Aten (2006).

Figure 5. Public Investment Management Index and Non-resource Sector Total Factor Productivity



Sources: Kyobe, Brumby, Papageorgiou, Mills and Dabla-Norris (2011), Heston, Summers and Aten (2006), World Bank (2011b) and authors' own calculations.

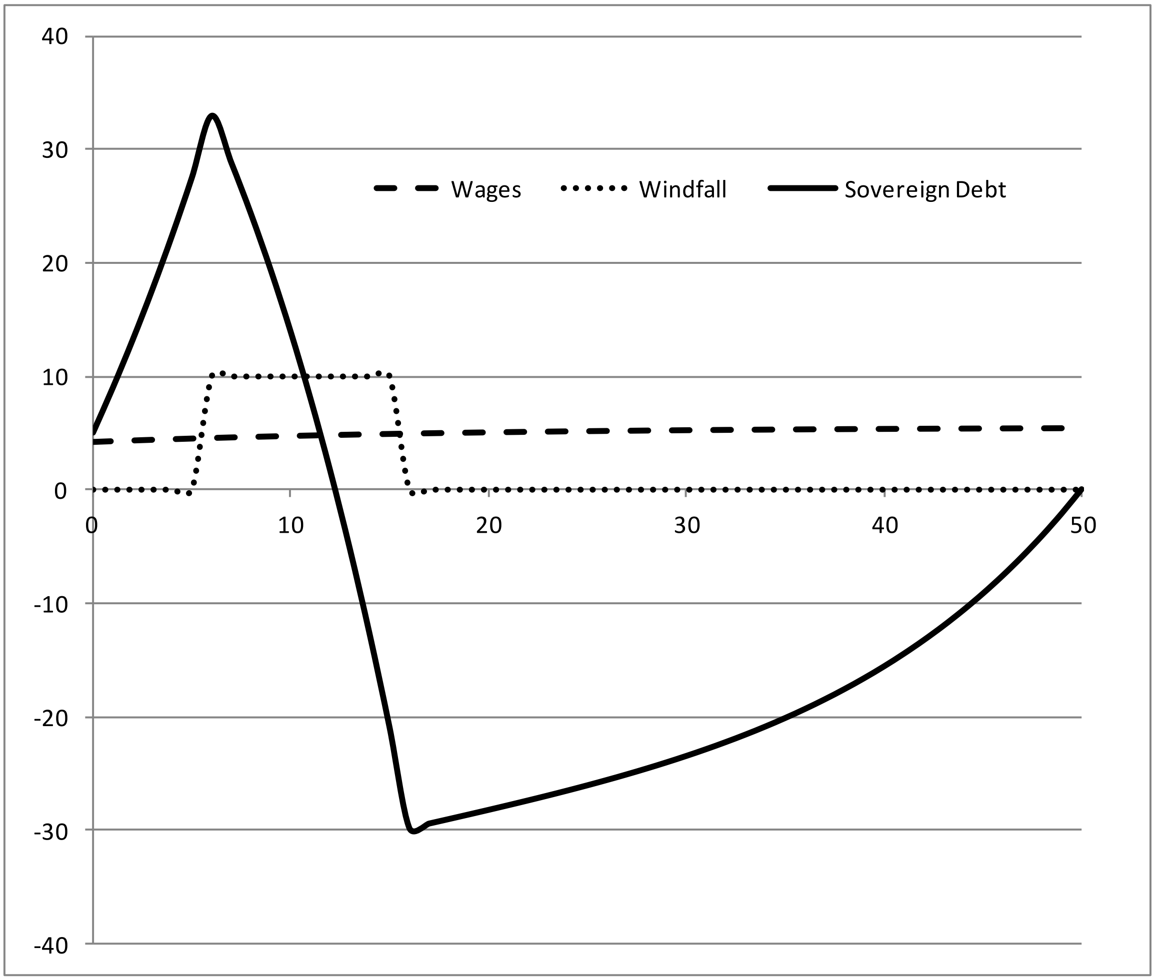
Figure 6. Resource Windfall, Consumption and Foreign Debt under the Permanent Income Framework



Source: Authors' own calculations.

Note: The parametrization used is as follows: initial debt Bo=40; non-oil GDP Y=100, non-oil revenue T=τY=15; oil revenue Z=15 for 40 years; discount factor β=0.96 implying an interest rate r=0.04. Spending describes the optimal level of public spending in the most basic permanent income framework and Asset describes the evolution of financial asset accumulated under this optimal path.

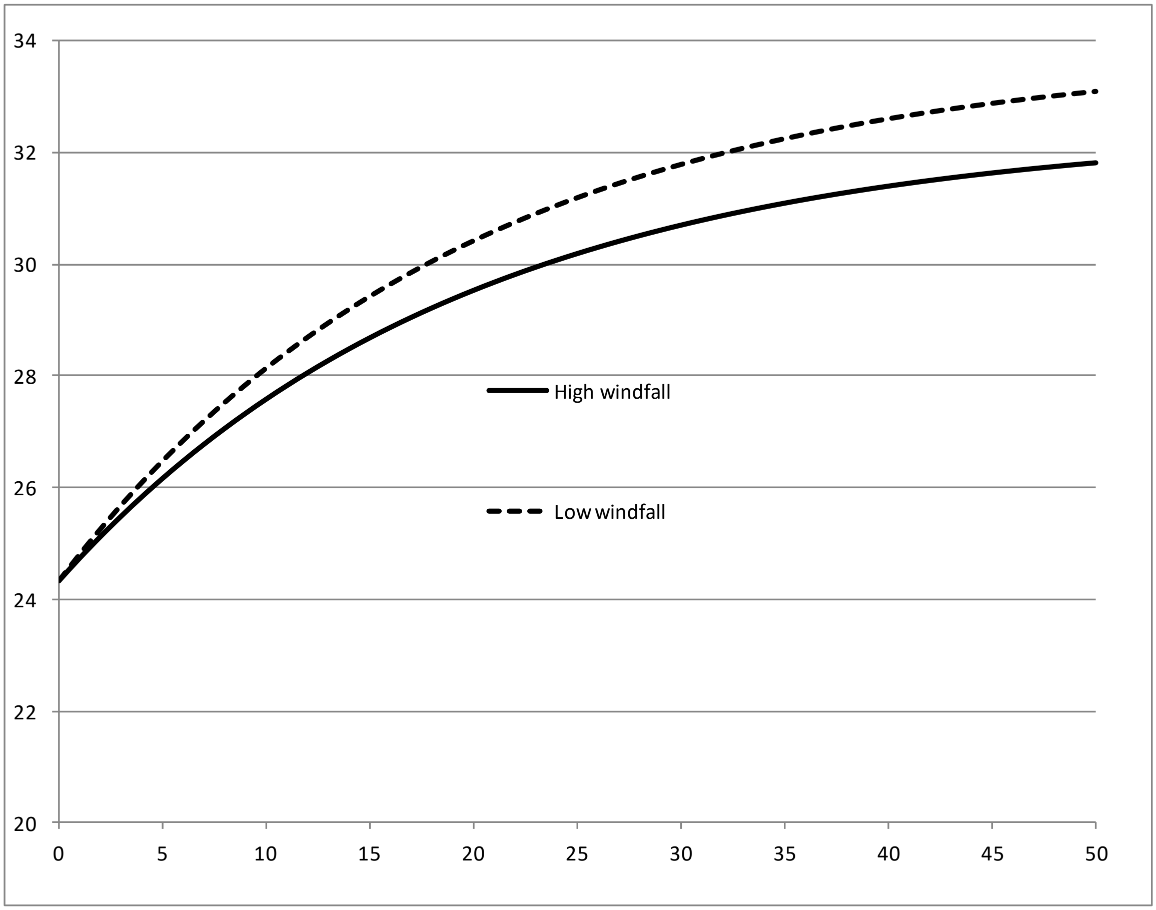
Figure 7. Evolution of Wages, Resource Windfalls and Sovereign Debt



Source: Authors' own calculations.

Note: Our parametrization is such that: $I_0 = I^*, S_0 = 0.75 \times S^*, F_0 = 5, N = 10, \delta_S = 0{,}05, \delta_K = 0{,}05, r^* = 0{,}08, A = 0{,}29, \gamma = 0{,}56\ and\ \bar{\alpha} = 0{,}1 + 0.005 \times V$. I_0: investment in public capital at t=0; I^*: steady state investment in public capital; S_0: initial stock of public capital at t=0; S^* : steady state stock of public capital; F_0 : level of sovereign debt at t=0; N: number of periods during which the resource windfall is non zero; δ_S : public capital depreciation rate; δ_K : private capital depreciation rate; r^* : world interest rate; A: total factor productivity ; γ: private capital income share; $\bar{\alpha}$: adjustment cost parameter ; V : net present value of the resource windfall.

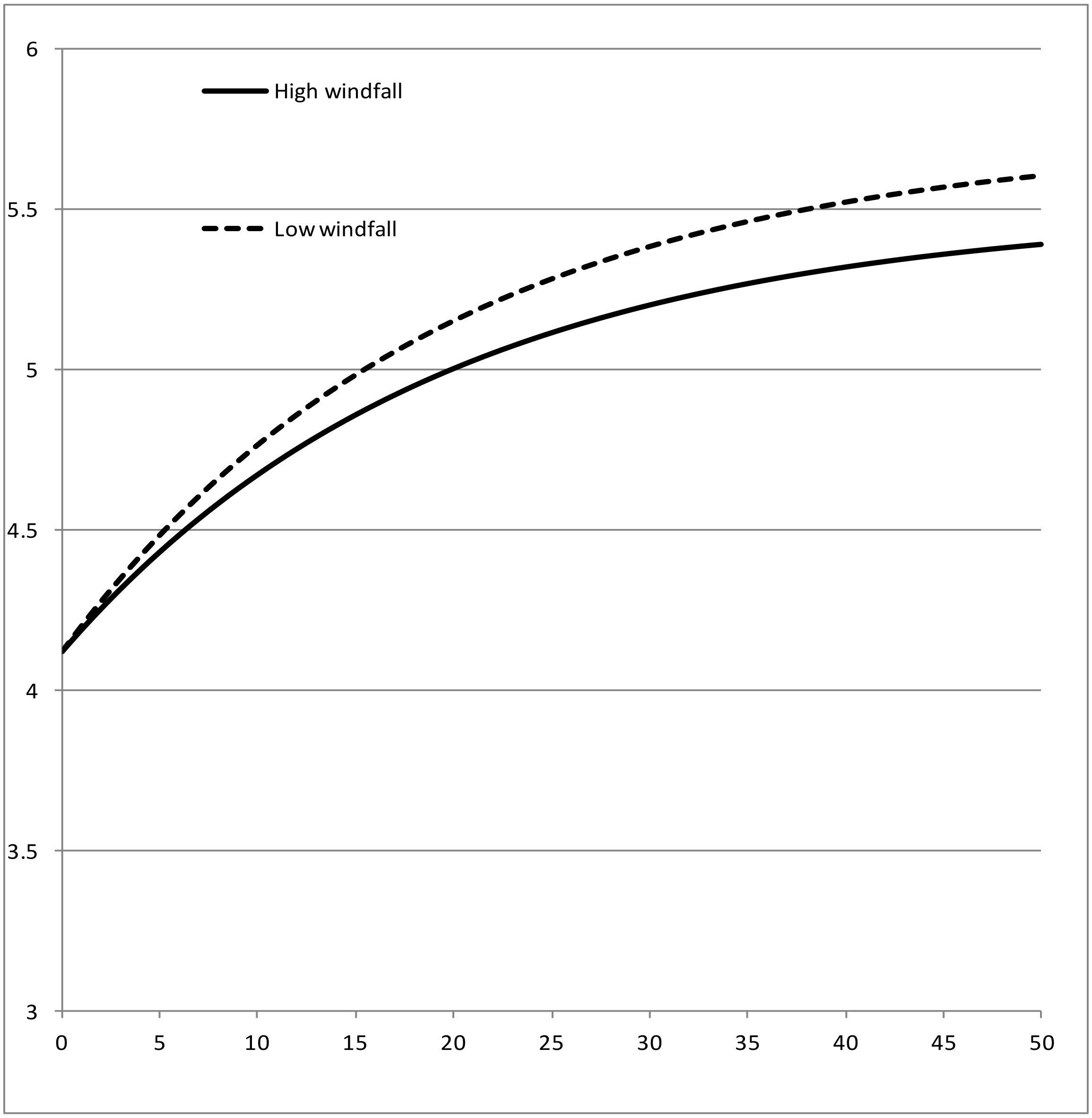
Figure 8. Evolution of the Stock of Public Capital under Different Scenarios



Source: Authors' own calculations.

Note: This figure corresponds to an experiment where we let two economies start from a similar steady state except for the respective size of their resource windfall at time, t_0. Recall that the adjustment cost depends positively on the present value of the windfall. This experiment allows us to compare the differences between economies in the evolution towards steady state of spending in public capital. We use our benchmark case parametrization to conduct the experiment.

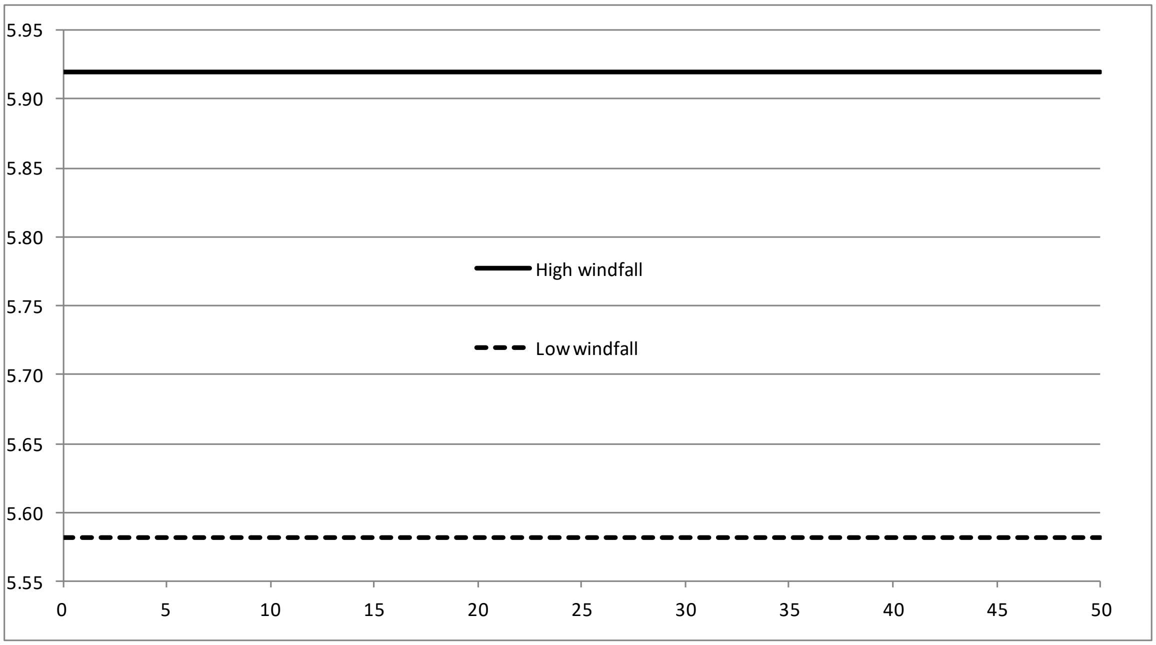
Figure 9. Evolution of Wages under Different Scenarios



Source: Authors' own calculations.

Note: This figure corresponds to an experiment where we let two economies start from a similar steady state except for the respective size of their resource windfall at time, t_0. Recall that the adjustment cost depends positively on the present value of the windfall. This experiment allows us to compare the differences between economies in the evolution towards steady state of spending in public capital. We use our benchmark case parametrization to conduct the experiment.

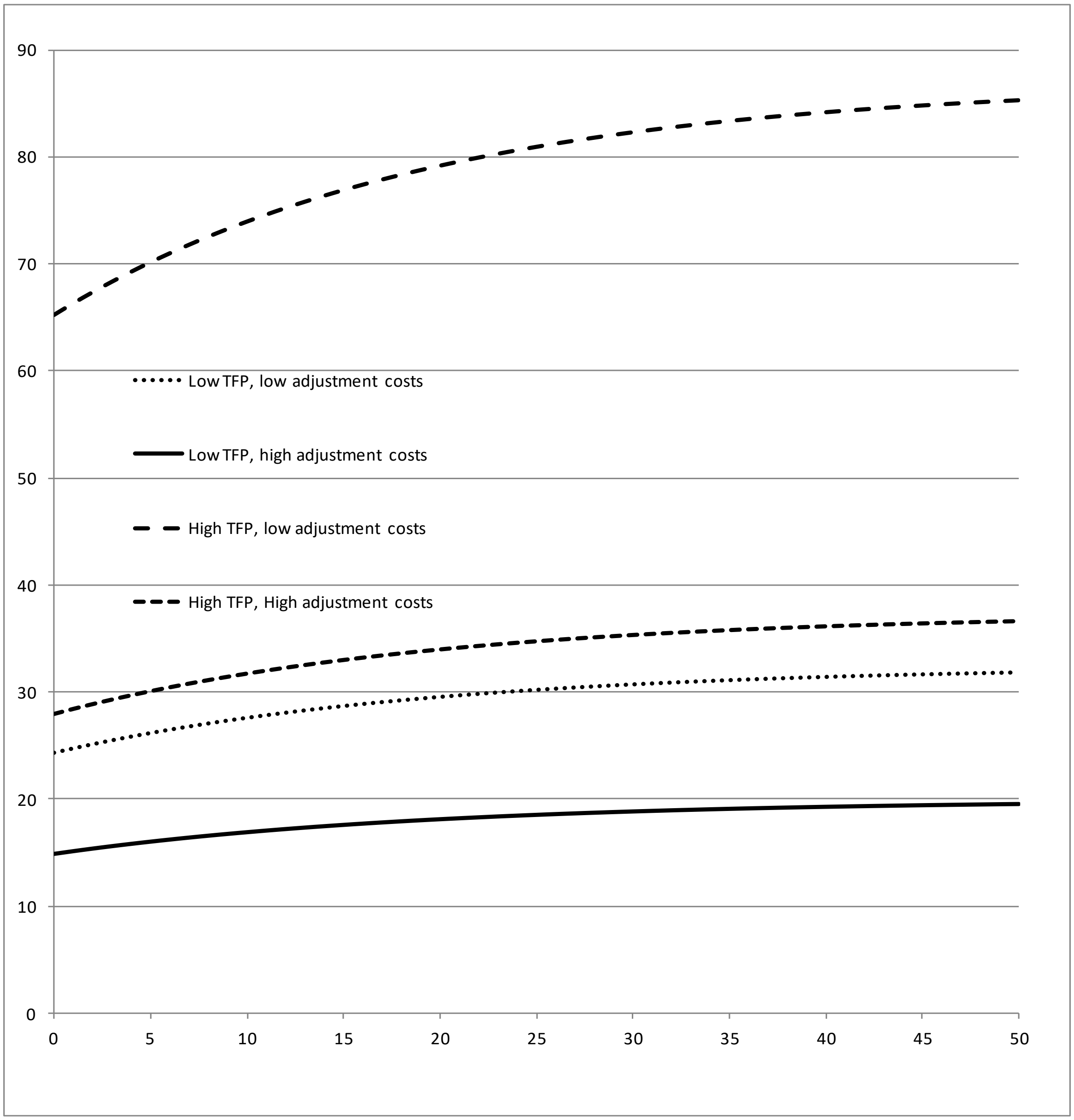
Figure 10. Evolution of Private Consumption under Different Scenarios



Source: Source: Authors' own calculations.

Note: This figure corresponds to an experiment where we let two economies start from a similar steady state except for the respective size of their resource windfall at time, t_0. Recall that the adjustment cost depends positively on the present value of the windfall. This experiment allows us to compare the differences between economies in the evolution towards steady state of spending in public capital. We use our benchmark case parametrization to conduct the experiment.

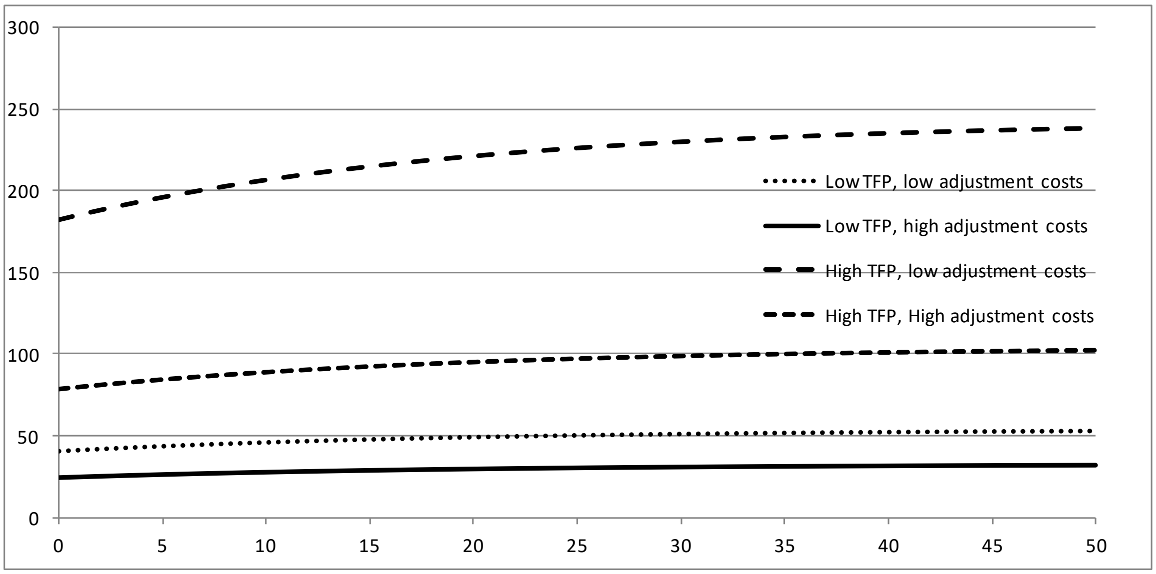
Figure 11. Evolution of the Stock of Public Capital under Different Scenarios



Source: Authors' own calculations.

Note: Our benchmark parametrization is such that: $I_0 = I^*, S_0 = 0.75 \times S^*, F_0 = 5, N = 10, \delta_S = 0{,}05, \delta_K = 0{,}05, r^* = 0{,}08, A = 0{,}29, \gamma = 0{,}56$ and $\bar{\alpha} = 0{,}1 + 0.005 \times V$. I_0: investment in public capital at *t=0*; I^*: steady state investment in public capital; S_0: initial stock of public capital at *t=0*; S^* : steady state stock of public capital; F_0 : level of sovereign debt at *t=0*; N: number of periods during which the resource windfall is non zero; δ_S : public capital depreciation rate; δ_K : private capital depreciation rate; r^* : world interest rate; A: total factor productivity ; γ: private capital income share; $\bar{\alpha}$: adjustment cost parameter ; V : net present value of the resource windfall. The benchmark parametrization corresponds to a "low TFP" and “low adjustment costs” scenario. We increase A by 0.075 for “high TFP” scenarios and the constant in $\bar{\alpha}$ by 0.7 for “high adjustment costs” scenarios.

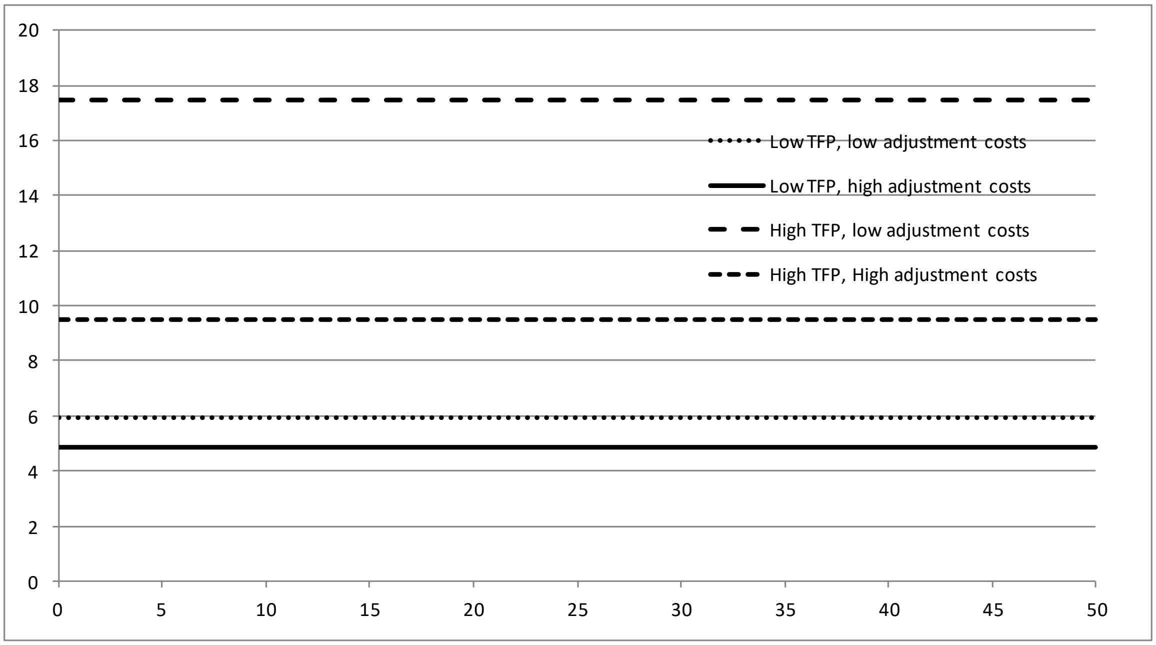
Figure 12. Evolution of the Stock of Private Capital under Different Scenarios



Source: Authors’ own calculations.

Note: Our benchmark parametrization is such that: $I_0 = I^*, S_0 = 0.75 \times S^*, F_0 = 5, N = 10, \delta_S = 0{,}05, \delta_K = 0{,}05, r^* = 0{,}08, A = 0{,}29, \gamma = 0{,}56$ and $\bar{\alpha} = 0{,}1 + 0.005 \times V$. I_0: investment in public capital at *t=0*; I^*: steady state investment in public capital; S_0: initial stock of public capital at *t=0*; S^* : steady state stock of public capital; F_0 : level of sovereign debt at *t=0*; N: number of periods during which the resource windfall is non zero; δ_S : public capital depreciation rate; δ_K : private capital depreciation rate; r^* : world interest rate; A: total factor productivity ; γ: private capital income share; $\bar{\alpha}$: adjustment cost parameter ; V : net present value of the resource windfall. The benchmark parametrization corresponds to a “low TFP” and “low adjustment costs” scenario. We increase A by 0.075 for “high TFP” scenarios and the constant in $\bar{\alpha}$ by 0.7 for “high adjustment costs” scenarios.

Figure 13. Private Consumption under Different Scenarios



Source: Authors' own calculations.

Note: Our benchmark parametrization is such that: $I_0 = I^*, S_0 = 0.75 \times S^*, F_0 = 5, N = 10, \delta_S = 0{,}05, \delta_K = 0{,}05, r^* = 0{,}08, A = 0{,}29, \gamma = 0{,}56 \; and \; \bar{\alpha} = 0{,}1 + 0.005 \times V$. I_0: investment in public capital at *t=0*; I^*: steady state investment in public capital; S_0: initial stock of public capital at *t=0*; S^* : steady state stock of public capital; F_0 : level of sovereign debt at *t=0*; N: number of periods during which the resource windfall is non zero; δ_S : public capital depreciation rate; δ_K : private capital depreciation rate; r^* : world interest rate; A: total factor productivity ; γ: private capital income share; $\bar{\alpha}$: adjustment cost parameter ; V : net present value of the resource windfall. The benchmark parametrization corresponds to a "low TFP" and "low adjustment costs" scenario. We increase A by 0.075 for "high TFP" scenarios and the constant in $\bar{\alpha}$ by 0.7 for "high adjustment costs" scenarios.