The Macroeconomic Effects of an Expanding Natural Resource Sector in Niger –

Dutch Disease in a Low-income Country, Revisited

Delfin Go
Sherman Robinson
Karen Thierfelder
Robert Utz[1]

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Introduction

Natural resources can contribute to economic growth and poverty reduction in Niger. Over the next two decades, Niger will see a dramatic increase in natural resource revenues which will greatly improve its external and fiscal position. In a brief period of time, exports of oil and uranium are expected to account for close to 20 percent of GDP by 2015 (from less than 8 percent in 2009). Likewise, total public revenue will reach 20 percent of GDP by 2015 (from less than 15 percent in 2009).[2]

The infusion of resource money will have to be used very wisely in order to address several challenges unique to Niger. After decades of political instability and turmoil, there is much ground to catch up. Niger's historical growth record has been very weak – for example, its per capita income growth was negative in the 1990s and stagnant in the 2000s. The country currently ranks near the bottom of the UNDP's human development index. Its poverty rate is high—about 44 percent of the population lives below $1.25 a day and 75 percent below $2 a day. Its adult literacy rate, at 29 percent, is among the lowest. Health indicators, such as maternal and child mortality, are very poor. In addition, Niger's terrain is

[1] Delfin S. Go – The World Bank; Sherman Robinson – International Food Policy Research Institute; Karen Thierfelder – U.S. Naval Academy; Robert Utz – The World Bank. The views expressed are those of the authors and do not necessarily reflect those of their respective institutions or affiliated organizations. We thank Sebastien Dessus, Alan Gelb… for various comments and suggestions.
[2] IMF country report for Niger, May 2012.

harsh and dry – more than 50 percent of Niger is desert; only 12 percent, mainly in the south, is cultivated; and only about 1 percent is forested. Subsistent agriculture, livestock and fishing constitute the backbone of the economy, employing 86 percent of the active population. The road and infrastructure network in this landlocked economy is still very limited. Lack of water is a major problem.

An important policy question will be how to harness the increased income from natural resources to bring about sustained growth and poverty reduction in Niger over a long period of time. Options include improving the productivity of agriculture with infrastructure investment, diversifying the economy away from mining and traditional agriculture, improving human capital, and maintaining a reserve fund as a safety net against world price shocks. The current government anticipates using revenue from natural resources to finance public investment in infrastructure, agriculture, health care, and education (IMF, March 2012). The government will also need to address a food crisis due to a poor harvest and security concerns along its border with Mali.

Even so, there are several issues and risks. In low-income countries, not only are spending needs relatively large and the growth of the tradable sector important for future income, capacity is likely low to optimize consumption over time or to hedge and stabilize revenue against fluctuating export prices. We briefly survey findings from the recent economic literature and its implications for Niger in a series of simulations. In particular, the effects of resource revenue on the real exchange rate and their economic repercussions have continued to receive wide attention in the literature. If the supply response or absorptive capacity is limited in the rest of the economy, the resource windfalls may induce a rapid appreciation of the real exchange rate, a loss of competitiveness in the non-resource export sector, deindustrialization of the traditional sectors, and poorer growth prospects overall for the economy. These potential harmful effects were labeled as "Dutch disease" when they were noticed in Netherlands after the discovery of North Sea gas.[3] In this paper, we examine Dutch disease in the context of Niger and its discovery of oil and uranium deposits. We will quantify the likely impact of the expansion of the extractive industries on Niger's real exchange rate and economy and suggest policy options to mitigate the negative impact of an appreciating exchange rate on Niger's international competitiveness.

We analyze the macroeconomic implications of an increase in revenue from export sales in a recursive dynamic computable general equilibrium (CGE) model for Niger, 2009. The underlying data for the model is a 2009 social accounting matrix (SAM), which is estimated and updated from the 2004 matrix using information from Niger's national accounts. The model includes private and public investment. Public capital increases infrastructure which is assumed to increase productivity growth. Note the SAM for 2009

[3] Corden and Neary (1982) and Wijnbergen (1984).

includes uranium production but not petroleum production. The two natural resources, oil and uranium, are modeled differently in this study. The discovery and extraction of petroleum will have an impact on the economy mainly through the increase in foreign revenue to government and the economy-wide repercussions of its use. The nascent oil sector is assumed to be a highly extractive and the revenue to Niger is only the government's share in its export revenues, assuming that petroleum production is financed mainly by foreign capital and foreign labor.

The baseline replicates the historical GDP growth for Niger. Policy shocks include an increase in revenue from export sales of oil and uranium – using estimates of the share of export revenue that accrues to the government. The revenue that goes to the government may directly increase public expenditures to provide public infrastructure, deliver education and health services, and pay for public administration. Alternatively, the income can go to households which spend most of their incomes on subsistence agriculture. For each simulation, we report the annual growth rate of GDP, investment, consumption, imports, exports, the real exchange rate, private capital, and public capital.

Although Niger's mineral revenue can bring about greater development, its use can clearly affect its external balance of payments (BOP) and debt situation. Without undertaking a new debt sustainability analysis (which is beyond the scope of this paper), a simple approach undertaken is to assume that no new debt burden is incurred at the margin over the horizon of the analysis – that is, whatever may be borrowed against future revenue in the initial periods is fully paid back at the end periods of the analysis. The model will be used to evaluate different timing options to spend the mineral revenue. Assuming the government can borrow against the expected oil revenue, one can evaluate the growth effects of different spending patterns of the extra revenue – for example, Niger can borrow and spend the expected oil revenue early in the dynamic simulation. However, against potential benefits of more public spending in the early periods are likely fiscal adjustments in the late periods in the form of fiscal revenue or expenditure consolidation needed to meet the debt obligations incurred. The magnitude and timing of the fiscal policy needed will in turn depend on many factors – the absorptive capacity of the Nigérien economy, the productivity of government spending, the growth of the economy and its tax base etc. We examine the economic implications of alternative assumptions or scenarios in this paper.

The remainder of the paper is organized as follows. Section 2 discusses the data and the structure of Niger's economy. Section 3 briefly describes the methodology or the recursive dynamic CGE model used for the analysis. Section 4 sets up the spending strategies regarding the mineral revenue. Section 5 presents the simulations and results. Our conclusions appear in section 6.

Overview of Niger's Economy

A 2009 SAM for Niger

Table 1. Sector aggregation for Niger 2009 SAM

Aggregate Sector	**Components from the 2004 SAM**
Food agriculture (subsistence agriculture)	Agriculture vivrière irriguée Agriculture vivrière non irriguée Elevage et pêche Forêt
Other Agriculture	Agriculture de rente irriguée Agriculture de rente non irriguée
Mines	Industrie d'extraction
Petroleum	Produits pétroliers
Food manufacturing	Fabrication aliments et boissons
Other manufacturing	Textiles et habillement Industrie chimique Autres manufactures Production des métaux
Construction	Construction
Utilities	Electricité, gaz, eau
Services	Transport et communication Services financiers Services immobiliers et aux enterprises Hôtels et restaurants Autres services Services communautaires et personnels
Public Services	Administration publique
Education & Health	Education Santé et services sociaux

Note: The original 2004 SAM was provided courtesy of the International Food Policy Research Institute (IFPRI).

The structure of the Nigérien economy has remained largely unchanged over the last decade and the backbone is still subsistence agriculture, reflecting the obstacles of industrializing or adding more value added with agro industries. To help understand the economic relationships in the Niger economy, we look at the data in Niger's Social Accounting Matrix (SAM). We begin by updating the 2004 SAM to 2009 using data from Niger's National Accounts by economic activity as compiled by the United Nations (UN 2009). Very briefly, the steps entail the following – i) the 2004 SAM is first aggregated into 11sectors (two sectors, petroleum and utilities, are not produced in Niger in 2009) – see Table 1; ii) the value added for each sector and final demand component are scaled to the 2009 numbers; iii) new data about the distribution of factor income for labor and capital, indirect and commodity taxes, and external accounts are incorporated; and iv) using the maximum-entropy method for estimating and balancing a SAM developed by Arndt, Robinson, and Tarp (2002), the 2009 SAM is derived by targeting key aggregates such as GDP and its final demand components, aggregate labor and capital income, tax revenue, exports and imports figures etc. In addition to having more recent data, the new SAM (albeit an estimated one) offers another advantage – it corrects the low level and share of capital income in the value added by sector in the 2004 SAM.[4]

There are seven factors in the 2004 SAM, which we aggregate to five factors - agricultural labor, land, unskilled labor, skilled labor, and capital. Table 2 presents the mapping:

Table 2. Factor aggregation in the 2009 SAM

Aggregate factors	**Factors from the 2004 SAM**
Agricultural labor	Travail agricole Travail des autres activités rurales
Unskilled labor	Travail du secteur informel Travail non qualifié du secteur privé formel Travail non qualifié du secteur public formel
Skilled labor	Travail qualifié du secteur privé formel Travail qualifié du secteur public formel
Capital	Rentiers
Land	Land is assumed to be 50% of the income reported to capital in the two agricultural sectors

Structure of the Nigérien Economy

Using data from the 2009 SAM, we consider the structure of consumption, production and trade (see table 3) in Niger. We find that agriculture (reported as food agriculture and other agriculture) and services have the highest shares in total consumption (22.8 and 22.4 percent respectively). Likewise, these two sectors have the highest share of total production. Niger depends heavily on imported goods – 26.5 percent of total consumption is imported. Important import sectors include manufacturing goods (90 percent of total consumption is imported), petroleum (100 percent of total consumption is imported) and utilities (100 percent of total consumption is imported); manufacturing is the largest import sector, accounting for 57.7 percent of total imports. The next largest import good is petroleum, which accounts for 13.3 percent of total imports, followed by utilities which accounts for 12.8 percent of total imports.

[4] The share of capital income was unusually low in the 2004 SAM – about 5.5 percent of value added.

Table 3. Structure of consumption, production, and trade (percent) in Niger, 2009

	Sector share of:					
	Consumption	Production	Imports	Exports	Import share of consumption	Export share of production
Food agriculture	17.2	20.1	8.4	18.6	13.0	13.6
Other agriculture	5.6	6.9	4.7	13.2	22.6	28.0
Mines	1.5	10.2	0.0	56.9	0.0	82.4
Processed food	10.3	11.4	2.2	0.8	5.7	1.0
Petroleum	3.5	0.0	13.3	0.0	100.0	0.0
Other manufacturing	17.0	3.3	57.7	9.0	90.0	40.1
Construction	5.7	6.6	0.0	0.0	0.0	0.0
Utilities	3.4	0.0	12.8	0.0	100.0	0.0
Services	22.4	26.0	0.9	1.5	1.0	0.9
Public services	6.0	7.0	0.0	0.0	0.0	0.0
Education/Health	7.3	8.5	0.0	0.0	0.0	0.0
Total	100.0	100.0	100.0	100.0	26.5	14.7

Source: Authors' calculations using the microeconomic SAM for Niger, 2009.

Table 4. Allocation of factors and value added by sector (percent) in Niger, 2009

	Agricultural Labor	Unskilled labor (non-agriculture)	Skilled labor	Capital	Land	Value added
Food agriculture	74.8	0.0	0.0	33.6	75.5	29.5
Other agriculture	25.2	0.0	0.0	10.9	24.5	9.7
Mines	0.0	3.3	1.7	20.1	0.0	7.8
Processed food	0.0	2.6	0.4	17.0	0.0	6.4
Other manufacturing	0.0	0.6	0.1	3.4	0.0	1.3
Construction	0.0	3.4	0.3	5.6	0.0	3.0
Services	0.0	82.6	14.7	6.7	0.0	30.9
Public services	0.0	4.0	40.5	2.6	0.0	6.1
Education/Health	0.0	3.4	42.4	0.1	0.0	5.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Authors' calculations using the microeconomic SAM for Niger, 2009.

Mining is the most important export good – it accounts for 57 percent of total exports. The majority of mining is exported – 82.4 percent of production. Agriculture is the next largest export, accounting for 31.8 percent of total exports.

Construction, public services, and education/health are purely non-traded goods.

As seen in Table 4, the service sector employs the majority of unskilled non-agricultural labor – 82.6 percent. The sectors public service and education/health employ 40.5 and 42.4 percent of skilled labor respectively. The majority of capital is employed in the two agricultural sectors, which employ 44.5 percent of the capital stock. The sectors mines and processed food employ 20.1 and 17 percent of the capital stock.

The mining and manufacturing sectors have high value added shares for capital which accounts for over 80 percent of total value added in each of the sectors (see Table 5). Likewise, there is a high share of capital in value added in the construction sector (61.6 percent).

Table 5. Share of value added to factors by sector (percent) in Niger, 2009

	Agricultural Labor	Unskilled labor (non-agriculture)	Skilled labor	Capital	Land	Value added
Food agriculture	25.5	0.0	0.0	37.2	37.2	100.0
Other agriculture	26.2	0.0	0.0	36.9	36.9	100.0
Mines	0.0	14.1	2.1	83.9	0.0	100.0
Processed food	0.0	13.2	0.6	86.2	0.0	100.0
Other manufacturing	0.0	15.9	0.9	83.2	0.0	100.0
Construction	0.0	37.5	0.9	61.5	0.0	100.0
Services	0.0	88.3	4.6	7.1	0.0	100.0
Public services	0.0	21.7	64.3	14.0	0.0	100.0
Education/Health	0.0	21.3	78.3	0.5	0.0	100.0
Total	10.1	33.0	9.8	32.7	14.5	100.0

Source: Authors' calculations using the microeconomic SAM for Niger, 2009.

As seen in Table 6, consumption patterns vary by agent. Households, particularly rural households, have the highest expenditure shares for food agriculture, followed by services and processed food. Government purchases public services and education/health. Both public and private investment spending is highest in construction and other manufacturing. Public investment also emphasizes spending on education/health. These different expenditure patterns suggest that income given to different agents will have very different impacts on the structure of the economy. For example, income to the government that is spent on current consumption will increase demand for non-traded goods.

Table 6. Expenditure shares by agent (percent) in Niger, 2009

	Rural HH	Urban HH	Capital owners	Government purchases for current consumption	Public Investment	Private Investment
Food agriculture	46.44	29.68	36.43	0.0	6.95	8.50
Other agriculture	4.38	7.45	2.47	0.0	0.09	0.39
Mines	0.00	0.00	0.00	0.0	2.80	3.26
Processed food	13.17	12.83	16.18	0.0	0.08	0.08
Petroleum	3.05	4.45	3.65	0.0	0.00	0.00
Other manufacturing	12.53	12.57	12.76	0.0	22.54	34.37
Construction	0.61	0.52	0.30	0.0	30.47	47.47
Utilities	2.74	2.48	4.78	0.0	4.98	0.00
Services	16.90	29.18	21.22	0.0	3.75	4.07
Public services	0.00	0.00	0.00	53.1	0.00	0.00
Education/Health	0.19	0.85	2.21	46.9	28.33	1.87
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Authors' calculations using the microeconomic SAM for Niger, 2009.

Methodology

We use a multi-sector computable general equilibrium (CGE) model of Niger to analyze how oil and uranium export revenue affects the economy. Like other resource-rich low-income countries, the significant capital investment required for resource extraction is financed by international companies and the returns accruing to Niger are captured primarily through government's share of mineral revenue in the form of taxation or royalties. The sophisticated skills needed to operate the mines are likewise assumed to be provided by foreigners and the production is taken as an enclave activity. Public revenue from the mineral resource is therefore modeled as an exogenous inflow to Niger, much like foreign aid and transfers.

The CGE model for Niger

In the framework, the economy is disaggregated into eleven sectors: food agriculture, other agriculture, mines, food manufacturing, petroleum, other manufacturing, construction, utilities, services, public services, and education/health.[5] There are 5 factors of production: agricultural labor, unskilled non-agricultural labor, skilled labor, land, and capital. There is both private and public investment. Private investment increases the stock of capital available to production the next time period. The amount of private capital available in the current year depends upon the stock of capital from the previous year, net of depreciation plus investment which depends upon savings. The capital stock reported in the 2004 Niger SAM is quite low – 5.5 percent of value added. Such low figure is contrary to most empirical results from

[5] In 2009, petroleum and utilities are imported and produced in Niger.

growth accounting, which tend to give relatively higher factor income shares to capital in low-income countries (as much as 50 percent or higher) and relatively lower share for wage income. The primary reasons for this pattern relate to the fact that capital is scarce and expensive in developing countries while labor, especially the unskilled in agriculture and services, are abundant and inexpensive. Partly for this reason, we update the 2004 matrix to 2009 in order to obtain better estimates of the factor income shares.

Since the data includes information about public capital and the structure of the economy, we can examine how government spending on public capital improves the economy's infrastructure and how better infrastructure improves total factor productivity by sector. Given that the economy consists mainly of subsistent agriculture and that the terrain is rough and varied, infrastructure will be a key factor to integrating supply and inputs, linking and mobilizing demand. We assume total factor productivity growth by activity is a function of the growth rate of public capital. In the base, there is no productivity and in selected simulations we consider the effects of total factor productivity linked to public infrastructure. We assume government investment as a share of government income (30 percent according to the microeconomic SAM for 2009) is constant.

The model is recursive dynamic with updates to labor and capital each time period.[6] Labor grows at an exogenous rate set at 3.5 percent per year. Land grows at an exogenous rate set at 1.5 percent per year. The capital stock grows as savings and the amount available for investment grows. There is also the option of allowing total factor productivity to grow each time period and/or factor embodied technological change each time period.[7]

The model includes both private and public capital.[8] In the base period, 32 percent of total investment is public investment, 68 percent is private investment. Investment in private capital increases the supply of capital to be used in production the next period. Capital accumulation is further explained below.

Foreign aid and foreign borrowing are exogenous and can be set over time. The interest on foreign borrowing is a function of the ratio of foreign debt to export earnings in the previous year.

Social welfare is a function of real household income and government income.

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[6] Model development to include recursive dynamics in a CGE model are similar to work done in Robinson and Thurlow (2004) and applied to Zambia in Lofgren, Robinson, and Thurlow (2004). In the model code for this analysis, there is also the option for agents to optimize over a set time period or epoch.
[7] When government spends more on education and health, one expects an increase in labor productivity in future time periods. We consider this option in simulations in which exogenous export revenue goes to the government which spends a large share of its income on education/health.
[8] See Turnovsky (1997) and Lofgren, Cicowiez, and Diaz-Bonilla (2013) for a discussion of public capital in general equilibrium models.

In this analysis we do not optimize the allocation of exogenous oil export revenue across agents (households, government, or private savings); nor do we optimize foreign borrowing. Instead, we explore the implications of an increase in exogenous export earnings.[9] We consider different spending options for the exogenous earnings.

Model closure assumptions include the following:

- Except for the rising exogenous inflows from mineral revenue, the rest of the current account balance is constant at base value, the real exchange rate varies to clear the current account (the nominal exchange rate is constant, domestic prices adjust, and the real exchange rate is the nominal exchange rate divided by the domestic price index.)

- Neoclassical macroeconomic closure – private investment is savings driven.

- Flexible real government expenditure - government savings is fixed but growing at a modest 2 percent a year. Government current expenditures and investment are fixed share of government income.

- The mobility of factors depends on the specification of the experiment. Labor by type is generally mobile across sectors (with agricultural labor used only in the two agricultural sectors and unskilled labor used only in the non-agricultural sectors); the labor supply growth rate is set exogenously at 3.5 percent a year. Land is only used in the two agricultural sectors and grows at 1.5% per year. Capital may be mobile or fixed depending on the simulation and is explained further below.

Reference scenario

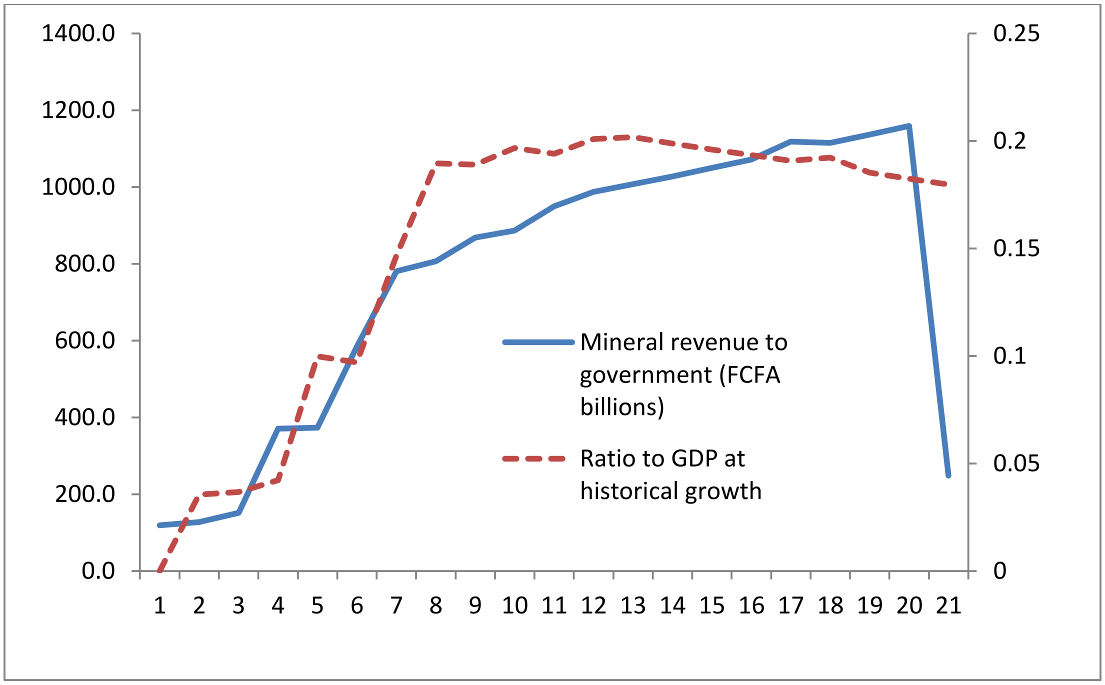
A baseline scenario is defined as the historical growth case of Niger. In this base case, GDP is the non-oil GDP from the base year 2009, growing by the historical growth rate of the 2000s, at 3.5 percent a year - that is, before the mineral oil revenue is expected to flow. It is therefore a low growth case without the benefit of the new revenue.

Against this baseline scenario, we introduce the effects of an exogenous increase in mineral revenue and various key assumptions as alternative scenarios. Figure 1 shows that the government share of mineral revenue is expected to be large relative to the size of the Nigérien economy, reaching as high as 20 percent of GDP. Hence, issues about absorptive capacity will be important. Furthermore, it has the typical hump shape reflecting an acceleration of production in the early stages and a rapid decline at the end as resources are

[9] We will explore inter-temporal optimization of oil export revenues in future work.

expected to be depleted. Although the revenue is sizable, it is still finite. Its optimal or economical use is therefore another crucial issue.

Figure 1: Projections of mineral revenue going to the government
(in FCFA billions and as percent share of GDP)



Source of data: World Bank and IMF staff calculations.

Options for managing the mineral revenue

Suggestions from Recent Literature

Economic literature has traditionally associated resource windfalls with problems related to the paradox of plenty – for examples, Dutch Disease (Corden and Neary, 1982), resource curse (Gelb, 1988, Auty 1993) – and more recently, conflicts (Collier and Hoeffler, 2004). Even so, Sachs and Warner, (1997) and van der Ploeg (2011) suggest both positive and negative outcomes are possible. Botswana, Chile and Norway are often cited as successful cases; that said, history is also beset with many failed cases, such as Bolivia, Congo, and Sudan. Several studies in recent years point to pathways by which resources can have a positive effects on growth: (i) good governance (Mehlum, Moene, and Torvik, 2006), (ii) openness to international trade (Arezki and van der Ploeg, 2012), (iii) countercyclical fiscal rules in the face of volatile mineral revenue (Frankel 2012 and Schmidt-Hebbel, 2012), and (iv) micro instruments or conditional cash transfers such as Progresa and Bolsa Familia in Mexico and Brazil to help poor people cope with income shocks from commodity price fluctuations and improve poverty reduction (Bourguignon 2012) etc.

Several new studies also highlight the practical policy problems of managing resource revenue in developing countries - Collier, van der Ploeg, Spence, and Venables, 2010; Baunsgaard, Villafuerte, Poplawski-Ribeiro, and Richmond, 2012; van der Ploeg and Venables, 2011; van der Ploeg, 2010; Arezki, Dupuy, and Gelb, 2010; Arezki, Pattillo, Quintyn, and Zhu, 2012; and Dixon, Kauzi, and Rimmer, 2010. Alternative prescriptions include policy rules relating to the permanent income hypothesis (PIH), sovereign wealth funds (SWF), Bird-in-hand (BIH), scaling investment and consumption in a capital scarce developing country, fiscal sustainability for resource rich developing countries, and coping with revenue volatility. Whatever mechanism chosen, defining that sustainable expenditure path will not be easy in a developing country facing several needs – when the marginal social value of consumption is high in the near term because the country is poor, when the social returns to investment is high because capital is scarce, and when the underlying market price for the resource is volatile. [10]

The parameter most relevant to the allocation of mineral revenue (or any project) over time is generally the social discount rate, which measure the revenue's opportunity costs or its value to the future whenever costs and benefits differ in their distribution over time. More than a few authors have therefore focused and debated about its value and implications in developing countries. A frequent approach to estimating the social discount rate is the Ramsey formula from the optimal long-run growth model with a representative consumer. In the context of intergenerational choice, it is often used to recommend a relatively low rate in order to protect future generations. Stern (2007), for example, uses it to explore the cost of climate change in the long-term. However, no discount rate could meet all the financing concerns and risk characteristics of every economic issue or project; tax distortions and competing use between private and public sectors also add to the calculation problems; issues are also raised about developing countries with scarce capital and low levels of income and consumption (see further below). Harrison (2010) reviews several practical difficulties and options.

In practice, different views and social discount rates are employed by countries. Environmental applications tend to use low discount rates. The United States Environmental Protection Agency recommends 2-3 percent; the World Bank has employed 10-12 percent; and the rates can range from 1 to 15 percent in various countries (see Harrison 2010 and Zhuang et al. 2007). Collier et al. (2010) argue that generational equity in a poor country requires that the discount rate should be high to attach more importance to the present when

[10] One option is that the savings rate from depleting resources varies inversely with the rate of change in the world price of natural resources. The Hotelling rule (1931) in resource economics postulates that the price of natural resources can be expected to increase at the world rate of interest. However, there is usually uncertainty about size of the global mineral reserves, demand conditions, and about future price paths. In addition to uncertain prices of natural resources, resource-rich countries in practice tend to follow different policies that are tailored to their distinctive circumstances. In particular, the saving and investment challenges in a resource-rich low-income developing country are many and the solutions are less clear cut.

consumption level is still very low and capital is still scarce, raising the point that as the economy grows, future generations will be richer than the present. Table 7 lists some of the discount rates, the associated parameters, and the implied growth in consumption.[11] As the numbers in the last column suggest, consumption growth can vary from a low 1 percent to a high 9 percent, which basically corresponds to how conservative or aggressive is the spending strategy being adopted.

Table7: Social discount rates from the Ramsey formula in selected studies

Source	Social discount rate, SDR	Pure rate of social time preference, ρ	Elasticity of marginal utility of consumption, σ	Growth rate in consumption, $\dot{C}/C$
Stern (2007)	1.4	0.1	1	1.3
Nordhaus (2007)	5.5	1.5	2	5.5
Weitzman (2007)	6.0	2.0	2	2.0
Arrow (2007)	2-6	0	2-3	1-2
Gollier (2006)	2.6-5.2	0	2-4	1-3
HM Treasury (2003)	3.5	1.5	1	2.0
Harrison (2010)	0.24-11	0	2-4	1.3
Dasgupta (2006)	2-8	0	2-4	1-2
Collier et al. (2010)				
Fast growing economy	10	If 1	1	9
Slow growing economy	2-3	If 1	1	1-2

Note: Zhuang et al. (2007) and Harrison (2010) compile many of these rates and others.

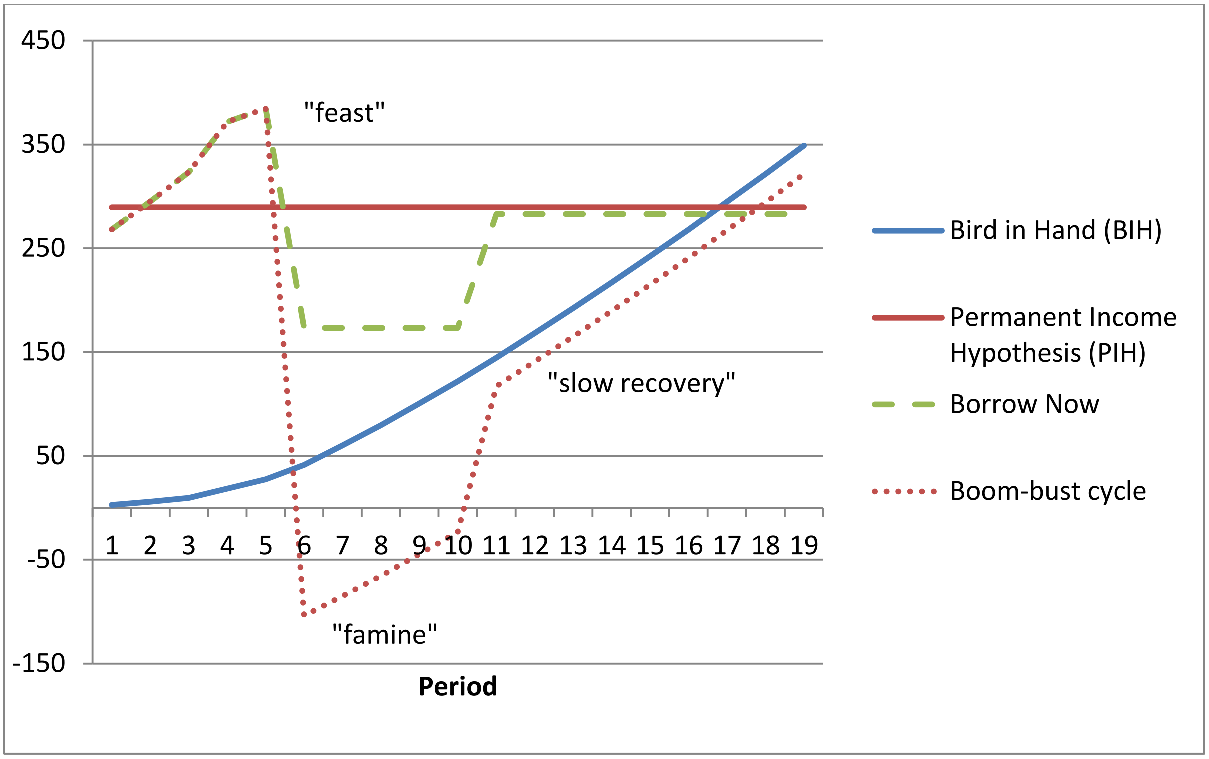
In view of the wide-ranging spending strategies suggested by the recent literature, we will focus mainly on three options in our simulations, which cover possible conservative to aggressive expenditure policy for Niger: 1) bird-in-hand (BIH) strategy; 2) permanent income hypothesis (PIH); and 3) borrow now to raise consumption and investment significantly in the short-term. Figure 2 illustrates the incremental spending for each option given the expected time path of mineral revenue.

[11] The Ramsey formula behind the numbers is

$$SDR = \rho + \varepsilon n + \sigma \dot{C}/C$$

where ρ is the rate of time preference; $\dot{C}/C$ is the expected rate of growth of consumption; ε depends on how changes in populations are valued and determines the effect of population growth, n; and the parameter σ is the elasticity of marginal utility of consumption that measures the value of marginal consumption to poor people relative to the richer. Most studies ignore population growth ($n = 0$) or a Benthamite social welfare function ($\varepsilon = 0$) where only total utility of all current and future household members matter.

Figure 2: Possible incremental spending in Niger under alternative strategies
(in FCFA billions)



Source: authors' calculations.

Bird-in-hand (BIH) strategy

All revenue is put in a foreign reserves or sovereign wealth fund (SWF) and incremental consumption or investment is restricted to the interest earned on the fund. This is a very conservative and cautious strategy for smoothing, with the windfall not valued until it has been banked. As the wealth accumulates, the income space for additional consumption is at the highest when the mineral reserve is depleted and interest income reaches the maximum. At that point, the interest income is close to 6 percent of the reference-run GDP, which confirms that the mineral revenue flows, especially when banked and accumulated, are significant in the case of Niger. The world interest rate assumed is 2.4 percent, the same rate used in the debt sustainability analysis for Niger (IDA and IMF 2013).

Although this option builds spending slowly, it has two advantages: it is the most feasible in terms of its minimal demand for institutional capacity to manage the resource fund; and it guards against any unexpected future drops in mineral export prices. Its disadvantage is obvious – it benefits the present generations the least when spending needs are the highest.

Strategy under permanent income hypothesis (PIH)

All new revenues are also transferred a sovereign wealth fund (SWF). Unlike the BIH option, it is assumed that Niger has good access to the financial markets and can execute the necessary financial contracts to optimize and smooth incremental spending, i.e., by achieving a steady interest income flow from the expected mineral wealth. Computationally, this simply means discounting all revenue flows to a present value and earning a constant interest income for spending, continually at the world interest rate.

If mineral production and revenue start immediately at the peak levels, both BIH and PIH options have the effect of transferring much of the consumption increases to future generations (the usual depiction in recent studies). However, because of the size and the hump shape of revenue in Figure 1 (when production starts slowly, before peaking and declining), this is not necessarily the case for the PIH strategy in Niger. The early periods already achieve significant increases in spending. Whether this strategy is feasible or not depends largely on Niger's capacity to manage a sovereign wealth fund in this manner.

Borrow now for higher spending in the short-term (Borrow Now)

If managing a sovereign wealth fund is difficult initially, an alternative is to build near-term spending by simple borrowing and debt accumulation. As the receiver of the mineral rents and taxes, the government is the central player to make the strategic spending and savings decisions to benefit present and future generations. One option is to borrow against future revenues in order to raise the low levels of consumption and capital stock.

As an illustrative scenario, we assume that spending level is raised for 5 years by an incremental amount equivalent to 8 percent of the reference-run GDP in the first year, gradually reaching 10 percent by the fifth year. In the sixth year, we assume that the government is able to put in place a sovereign wealth fund to affect a PIH strategy as described above. However, it also has to pay back the new external debt. It does this by amortizing the accumulated debt and its interests through equal payments for 5 years. This explains the shape of the "Borrow Now" curve in figure 2. Relative to the BIH and PIH options, this strategy benefits the present generations more while still protecting the future generations with significant amount of future spending. Compared to the PIH, spending in the middle periods when debt is being repaid is lower.

A boom-bust cycle possibility. This is essentially the aggressive borrow-now strategy with a very poor outcome. The borrowing strategy as described above depends very much on two assumptions. First, the government is able to put in place an SWF and smooth spending in time, starting in year 6. Second, the government is able to undertake the necessary fiscal adjustment to pay back the external public debt, also by year 6. We assume the fiscal adjustment is realized by means of lump-sum taxes on households (but we do not preclude other taxes or spending cuts). If these actions are not available, the strategy will require dipping into the future mineral revenue and wealth to pay for the external debt, causing a significant delay of what is the only option left possible, a BIH route. The "Boom-bust" curve in Figure 2 depicts the risky pattern and trade-offs in this lower case – an initial period of significant increments in spending ("feast"), followed by a rapid fall in spending in the medium-term period when debt reduction and fiscal consolidation has to take place ("famine"), and a BIH period that kicks in later than the straight BIH strategy ("slow recovery"). If in addition the spending is wasted in the sense that no productivity is gained, this could become a "Boom-Bust" scenario associated with the resource curse in the literature. This is true of any spending plan that has little productivity effect and that dips into the "capital" (the revenue flow and accumulated wealth) in the short term, but paying for it fiscally while necessitating a more conservative spending path in the future.

Simulations and results

We explore different smoothing strategies in a recursive dynamic model of Niger, with the incremental changes to income described in Figure 2.

Productivity, supply response, and Dutch disease.

Two sides of the Dutch disease problem reflect the quantity versus the price response of the economy to a significant exogenous inflow of revenue. When 'quantity' or supply in the economy is unable to response quickly to the exogenous inflow of mineral revenue, relative prices will tend to overshoot in the short-term in favor of non-tradable goods. The key relative price is the real exchange rate, which is the relative price of tradable and non-tradable goods. The overshooting of exchange rate is an appreciation that goes against tradable goods because prices for tradable goods are constrained by world prices in an open economy, so that most of the price increases arising from the extra income and demand will come from non-tradable goods like construction and services. This temporary overshooting of relative prices could create permanent problems if it causes the non-mineral tradable sectors to shrink over time, becoming incapable of providing new sources of growth when the mineral revenue is exhausted.[12]

[12]Similar issues may be encountered in developing countries when foreign aid is scaled up significantly (see Adam 2006).

Hence, supply productivity, flexibility and growth will likely affect the degree of the Dutch disease. Figure 3 illustrates the real exchange effects under the PIH spending strategy and two conditions – rising productivity and output over time and the mobility (responsiveness) of capital:

- As may be recalled, the PIH strategy already entails significant resource income and spending in the near future. Hence, the real exchange rate will appreciate (fall below 1.00) immediately. As output rises over time, the real exchange rate recovers and will eventually depreciates in the long-run. This is a case where productivity increases as government spends more on education, health and infrastructure to raise human and public capital. About 30 percent of the government income is spent on public capital or infrastructure, the remainder is spent on current consumption for either education/health (47 percent of spending on current consumption) or public infrastructure (53 percent of spending on current consumption) The crucial assumption is that public spending on education, health, and infrastructure is productive and will raise productivity especially in the tradable sectors.

- Moreover, when capital is mobile across sectors (responsive supply within each period), the real exchange rate appreciates slightly less than when capital is fixed once installed (rigid supply in the short-term). In the latter case, capital responds to the relative rates of returns across sectors through new investments, following the formulations of Dervis, de Melo, and Robinson (1982) for a developing country. In the long run, real exchange rate also depreciates less in the case where capital is mobile, underlining further the importance supply flexibility.

Figure 3: Real exchange rate under alternative supply and productive behavior

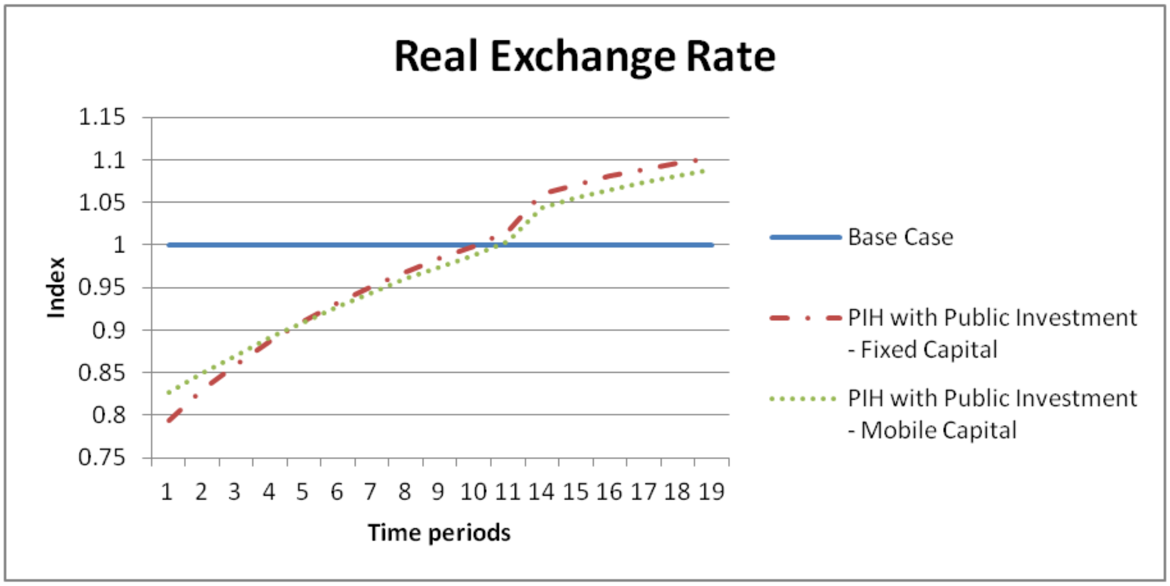


Table 8 shows the other side of the Dutch disease problem, the quantity response in terms of the GDP shares of the traded sectors, semi-traded sectors, and non-traded sectors. When the exogenous mineral revenue is first received, the non-traded goods expand and their value-added share increases the most among the three types of sectors. This contrasts with the decreased share for traded goods immediately. Moreover, when capital is fixed there is slightly less of a supply response than when capital is mobile. Overtime, the pattern is reversed and the share of traded goods will eventually increase when there are significant productivity and output growth in those sectors.

Table 8: Shares of real GDP value added by type of sectors

		Initial Year of Exogenous Income		Terminal Year of Exogenous Income	
	Base	PIH with Public Investment - Fixed Capital	PIH with Public Investment - Mobile Capital	PIH with Public Investment - Fixed Capital	PIH with Public Investment - Mobile Capital
Traded Good	8.16	7.17	6.64	10.94	11.07
Semi-Traded Good	46.60	46.41	45.72	45.48	45.56
Non-traded Good	45.23	46.43	47.64	43.58	43.37

Source: Model simulations.

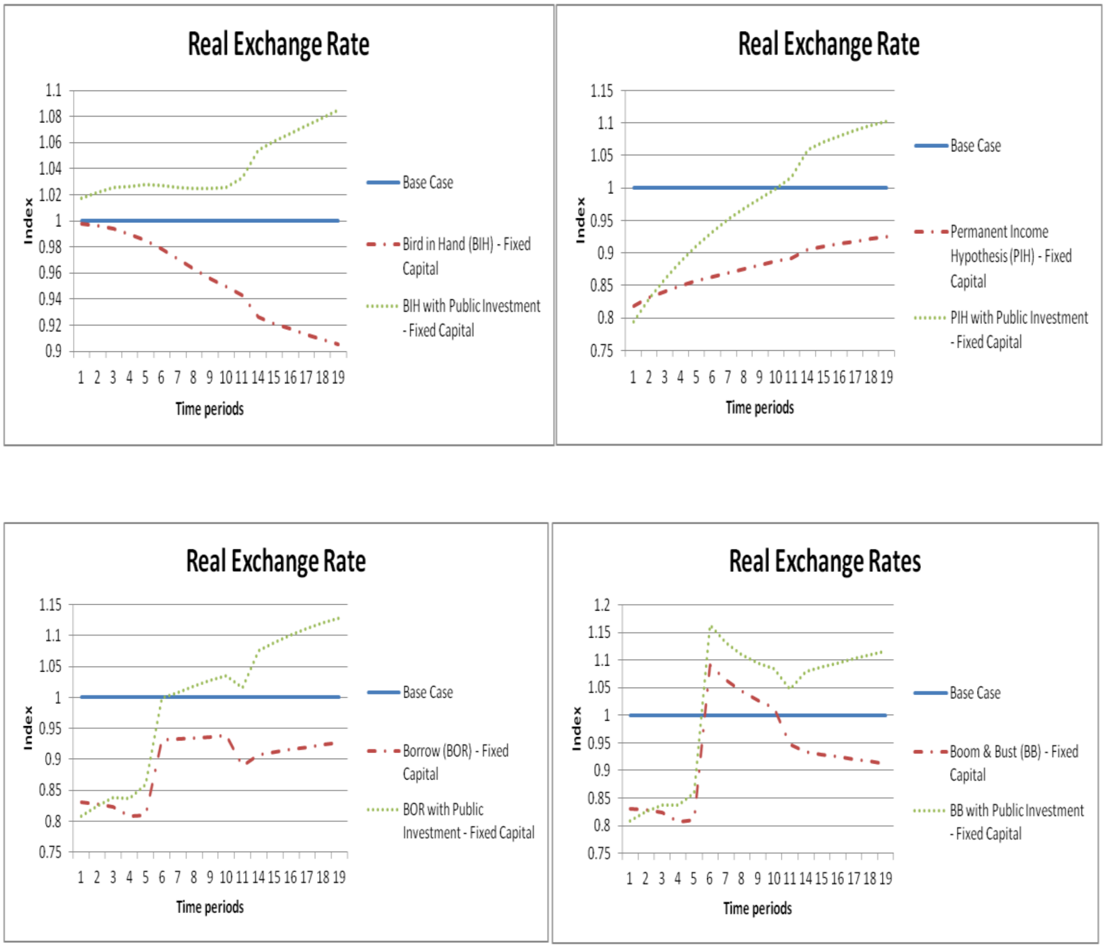
Note: traded goods = mining which is exported only, there are no imports; Semi-traded goods = food agriculture, other agriculture, food manufacturing, other manufacturing, there are both imports and exports; and non-traded goods = construction, services, public services, and education/health, there are no imports or exports (with the exception of services which has a very small share of consumption imported and a very small share of production exported).

Real exchange effects of alternative spending strategy

In what follows, we assume that capital is fixed once installed as this is more realistic for a developing country like Niger. New investment is allocated each period based on the relative rate of returns of each sector.

Figures 4 to 7 shows the real exchange effects of each spending strategy, For each strategy, we compare the case where money is used mainly for consumption and the case where money is used to raise human and public capital. In the consumption case, households receive the mineral revenue through lump-sum transfers from government and spend it primarily for consumption, saving a small portion for investment. We further assume that consumption and investment by households in a subsistence economy are diffused and do not raise productivity very much. To be sure, the assumption is made mainly for simplicity and to distinguish the effects of consumption and investment.

Figures 4 to 7: Real exchange rate effects under alternative strategy – consumption versus investment



The following summary observations may be made:

- In the short-term, the real exchange rate will appreciate straightaway under all spending strategies except under the most conservative spending plan, the BIH. In other words, the Dutch disease will be less evident initially in the BIH case, but will still register over time if there are no significant investment and productivity gains.

- The appreciation relative to the base run appears permanent in the long-run under all spending cases when spending is primarily for consumption. When there is significant investment to raise productivity and output growth, the appreciation will ameliorate and reverse itself (depreciate) over time.

- In the worst case, the boom-bust case, the repayment of debts through fiscal adjustment will reduce spending and the real exchange rate will depreciate during the middle-periods.

Macroeconomic effects of alternative spending strategy

Table 9 shows the effects on Niger's economy under alternative spending plan. We make the following observations:

- When there is significant investment and productivity, GDP (non-oil) may grow by 6.8 to 7.5 percent a year and consumption may rise by 7 to 7.7 percent a year. Although there are differences across spending plans, the differences are quantitatively minor. This is true also in the two borrowing cases.

- Even so, the "Borrow-Now" strategy has the potential of raising average output growth slightly more if spending raises investment and productivity, despite some adjustment in the middle periods. We discuss this further in the next subsection.

- When resources are consumed rather than invested primarily, GDP growth will not improve relative to the base case in all spending plans. Aggregate consumption will grow slightly more than the base case, but nowhere near the cases where investment raises output growth.

Table 9: Macroeconomic effects under alternative spending plan

Real Average Annual Growth Rate over the 22 year period

	Base Case	Bird in Hand (BIH)	BIH with Public Investment	Permanent Income Hypothesis (PIH)	PIH with Public Investment	Borrow (BOR)	BOR with Public Investment	Boom & Bust (BB)	BB with Public Investment
Consumption	3.69	4.06	7.04	3.97	7.21	3.97	7.66	4.02	7.53
Private Investment	4.47	4.36	5.84	4.40	5.92	4.40	6.19	4.37	6.12
Public Investment	5.88	6.04	9.93	5.98	9.95	5.98	10.40	6.01	10.34
Total Investment	4.97	4.97	7.53	4.97	7.58	4.97	7.94	4.96	7.87
Government	1.98	2.07	5.31	2.06	5.39	2.06	5.85	2.06	5.76
Exports	4.50	3.72	8.36	3.75	8.64	3.77	9.28	3.82	9.11
Imports	4.14	4.43	7.22	4.33	7.34	4.33	7.80	4.40	7.70
GDP (at mkt prices)	3.52	3.48	6.84	3.47	7.03	3.47	7.52	3.48	7.38

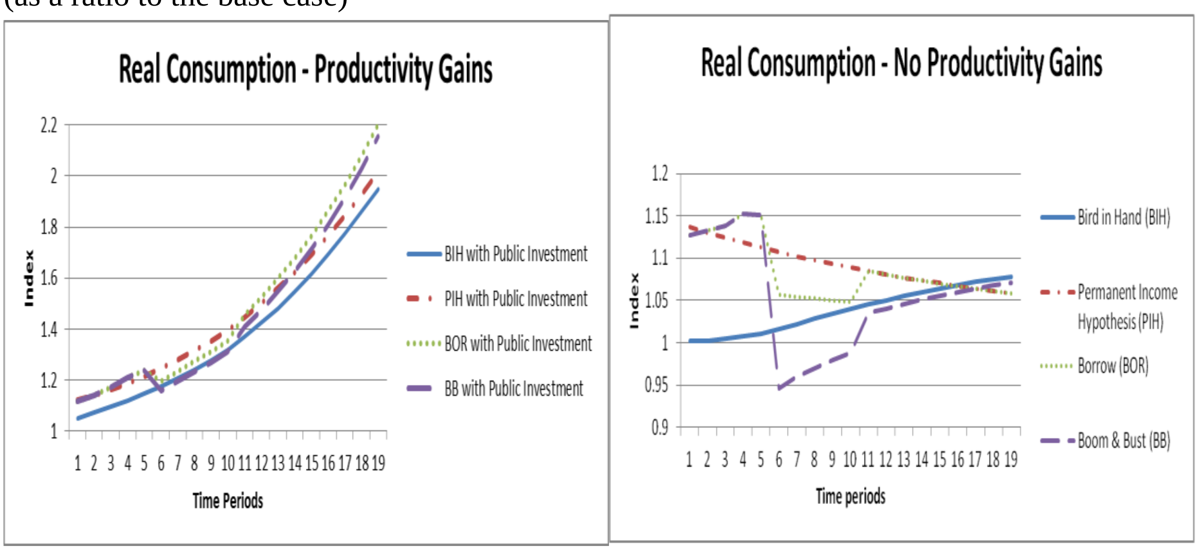
Source: Model simulations.

Behavior of consumption over time

Figure 8 and 9 show the effects on consumption over time. When there are productivity gains from investment and spending, consumption will grow steadily over time relative to the base case, appearing to benefit similarly across alternative spending plans. The dip in consumption during the middle periods for the "Borrow Now" or "Boom-bust cycle" seems small. At the end of the simulations, consumption is close to twice the reference level in the conservative BIH case and more than twice the reference case in the other spending plan.

When there are no productivity gains, the timing and changes in consumption become distinct across the spending plans. Consumption in the PIH and "Borrow-Now" cases start at a high level relative to the BIH case, but all three will converge to about 5 to 10 percent higher than the reference case at the end of the simulations, much lower than the cases with productivity gains in the first graph. There is the expected dip in consumption during the middle periods for the "Borrow now" case. However, when smoothing is not possible even in the future, the fiscal adjustment and debt repayments in the low case scenario will lead to a big drop in consumption from their initial high levels, leading to negative deviations from the reference values during the middle periods (as high as -5 percent), before rising and converging eventually to the levels of the other spending plans. Herein lies an illustration of the risks and cautionary tale of the resource curse – a case of overspending and borrowing with little or no productivity, followed by fiscal adjustment and contraction, before attaining a slow recovery.

Figure 8 and 9: Real consumption over time across spending plans
(as a ratio to the base case)



Output by aggregate sectors

Table 10 Annual growth rates of real output by aggregate sectors

	Initial Period (Y1-Y5)	Middle Period (Y6-Y10)	All Periods (Y1-Y22)
Traded Goods			
Base Case	5.30	5.14	5.08
Bird in Hand (BIH)	4.95	4.12	4.27
Permanent Income Hypothesis (PIH)	3.21	5.36	4.91
Borrow (BOR)	2.01	6.25	4.90
Boom & Bust (BB)	2.01	6.42	4.96
BIH with Public Investment	7.76	7.81	9.04
PIH with Public Investment	8.16	10.02	10.22
BOR with Public Investment	6.90	10.70	11.03
BB with Public Investment	6.90	8.86	10.84
Non-traded Goods			
Base Case	3.71	3.67	3.65
Bird in Hand (BIH)	3.75	3.77	3.71
Permanent Income Hypothesis (PIH)	3.69	3.56	3.59
Borrow (BOR)	3.81	3.59	3.59
Boom & Bust (BB)	3.81	3.93	3.62
BIH with Public Investment	5.84	6.55	7.20
PIH with Public Investment	6.96	6.32	7.10
BOR with Public Investment	7.41	6.19	7.76
BB with Public Investment	7.41	6.04	7.65
Semi-traded Goods			
Base Case	3.71	3.72	3.70
Bird in Hand (BIH)	3.72	3.74	3.71
Permanent Income Hypothesis (PIH)	3.85	3.64	3.69
Borrow (BOR)	3.85	3.58	3.70
Boom & Bust (BB)	3.85	3.47	3.71
BIH with Public Investment	6.13	6.81	7.44
PIH with Public Investment	6.99	7.34	7.78
BOR with Public Investment	6.89	7.21	8.24
BB with Public Investment	6.89	6.42	8.09

Source: Model simulations.

Note: traded goods = mining which is exported only, there are no imports; Semi-traded goods = food agriculture, other agriculture, food manufacturing, other manufacturing, there are both imports and exports; and non-traded goods = construction, services, public services, and education/health, there are no imports or exports (with the exception of services which has a very small share of consumption imported and a very small share of production exported).

Table 10 shows the growth rates of sectoral outputs grouped according to traded goods, non-traded goods, and semi-traded goods. All sectors tend to grow at higher rates when there are productivity gains from public spending on infrastructure, education and health. This is particularly true for traded goods – their growth will start high in the initial periods (year 1 to 5) and accelerate the most in subsequent periods. When there are no productivity gains, the effects of Dutch disease are reflected by slower growth rates in traded goods, particularly in the two cases associated with borrowing in the initial periods – Borrow (BOR) and Boom & Bust (BB).

Conclusions

We examine three spending plans suggested by the recent literature regarding Dutch disease and examine their implications to Niger relative to its expanding mineral sector. The spending strategies include – 1) Bird in hand (BIH), 2) Permanent income hypothesis and 3) Borrow now options. The reference case is a historical growth run where GDP and real consumption grow slowly by 3.5 and 3.7 percent, respectively, before the impact of significant inflow of mineral revenue.

Under each of the spending scenario, real consumption will grow by over 7 percent a year over the 20-year period when there are productivity gains in the investment in infrastructure and when there are positive effects on human capital from government spending on education and health. When spending is mainly for consumption with no productivity advances, real consumption is about 4 percent a year across spending plans, only slightly higher than the reference case of slow growth.

Although the average growth rate of consumption appears stable, they differ markedly in timing and pattern, especially when spending does not raise productivity. Here, there is an early increase in real consumption in the more aggressive spending plans, but it will result in negative deviations from the low levels of consumption of the reference case if fiscal adjustment and debt repayments result in contraction and the government is unable to smooth consumption even in the future. This is a caution against expectations that exaggerate the benefits of mineral revenue under all circumstances.

The key to the benefits of significant mineral revenue lies with the productivity and supply responses of spending. If significant output gain is assured, then there is very little difference across the spending plans in their effects on real consumption. We further conduct sensitivity tests regarding the mobility of capital and show that the Dutch disease in terms of the overshooting of relative prices or the shrinking share of traded sectors in GDP can be ameliorated with greater supply flexibility. In the end, the main constraint of the more aggressive spending plans like the PIH and Borrow-Now options will be the institutional capacity to manage a sovereign wealth fund to effect consumption smoothing in the early or middle periods.

The BIH has the least demand on managing the mineral wealth. It will raise real consumption over time and if coupled with productivity gains in spending, the Dutch disease will be less or not be evident.

Future work

In this analysis, we use a recursive dynamic model to analyze the effects of an exogenous increase in oil revenue. For future work, we will optimize over timing and spending source of exogenous oil revenues.

To further analyze development strategies for Niger, we can investigate the links between spending on sectors such as health and education impact labor productivity. An analysis using a MAMS (Maquette for MDG Simulations) approach would provide a better explanation of total factor productivity growth.[13]

Finally, in this analysis, we treat export revenue from the sale of a natural resource (oil) as an exogenous increase in income – we are interested in how that income is spent in the economy. This is a reasonable description of the oil sector in Niger. China is providing the labor and capital to extract crude oil in Niger; the impact on Niger is via the revenue from oil sales. For other natural resources, a change in output to increase exports can impact the economy as resources are used in that natural resource sector. Mining is labor intensive, using unskilled labor in Niger that could also be used in other sectors. When uranium production expands, other sectors will see a cost of increased input costs as the uranium production competes with other sectors for factor inputs. We will expand our analysis to include the structural changes that occur as the expanding natural resource sector competes for domestic inputs to production.

References

Adam, Christopher. 2006. "Dutch Disease – Where Do We Stand?" In Isard, Peter, Leslie Lipschitz, Alexandros Mourmouras, and Boriana Yontcheva, eds., *The Macroeconomic Management of Foreign Aid – Opportunities and Pitfalls.* Washington, D.C.: International Monetary Fund.

[13] See Logren et al. (2013).

Arndt, Channing, Sherman Robinson, Finn Tarp. 2002. "Parameter Estimation for a Computable General Equilibrium Model: A Maximum Entropy Approach," *Economic Modeling*, 19(3):375-98.

Arezki, Rabah, Arnaud Dupuy, and Alan Gelb. 2012. "Resource Windfalls, Optimal Investment and Redistribution: The Role of Total Factor Productivity and Administrative Capacity." IMF Working Paper WP/12/200. Washington, D.C.: International Monetary Fund.

Arezki, Rabah, Catherine Pattillo, Mark Quintyn, and Min Zhu, Eds., 2012. *Commodity Price Volatility and Inclusive Growth in Low-Income Countries.* Washington, D.C.: International Monetary Fund.

Arezki, R. and F. van der Ploeg. 2008. "Can the Natural Resource Curse be Turned into a Blessing? Role of Trade Policy and Institutions." IMF Working Paper 07/55, Washington, D.C.: International Monetary Fund.

Arrow, K. 2007. "Global Climate Change: A Challenge to Policy." *Economists' Voice*, June, pp. 1-5, http://www.bepress.com/ev..

Auty, R. M. 1993. *Sustaining Development in Mineral Economies: The Resource Curse Thesis.* London, Routledge.

Baunsgaard, Thomas, Mauricio Villafuerte, Marcos Poplawski-Ribeiro, and Christine Richmond. 2012. "Fiscal Frameworks for Resource Rich Developing Countries." IMF Staff Discussion Note, May 16, 2012. SDN/12/04. Washington, D.C.: International Monetary Fund.

Bourgugnon, François. 2012. "Commodity Price Volatility, Poverty, and Growth Inclusiveness in Sub-Saharan African Countries." In Arezki, Rabah, Catherine Pattillo, Mark Quintyn, and Min Zhu, Eds., pp. 187-224.

Collier, P. and A. Hoeffler. 2004. "Greed and Grievance in Civil War." *Oxford Economic Papers*, Vol. 56, No.4, pp.563-95.

Collier, Paul, Rick van der Ploeg, Michael Spence, and Anthony J. Venables. 2010. "Managing Resource Revenues in Developing Countries." *IMF Staff Papers*, Vol. 57, No. 1, pp. 84-118.

Corden, W. Max and J. Peter Neary. 1982. "Booming Sector and De-industrialisation in a Small Open Economy." Economic Journal, 92(368): 825-48.

Dasgupta, P. 2006. “Comments on the Stern’s Review on the Economics of Climate.” December 12. Seminar organized by the Foundation for Science and Technology at the Royal Society, London.

Dervis, Kemal, Jaime de Melo, and Sherman Robinson. 1982. *Geenral Equilibrium Models for Development Policy.* Cambridge: Cambridge University Press.

Dixon, Peter B., Gae Kauzi, and Maureen T. Rimmer. 2010. “ Effects on the PNG Economy of a Major LNG Project,” *Economic Papers* 29(2): 143-155.

Frankel, Jeffrey (2012). “The Natural Resource Curse: A Survey of Diagnoses and Some Prescriptions.” In Arezki, Rabah, Catherine Pattillo, Mark Quintyn, and Min Zhu, Eds., pp. 7-34.

Gelb, Alan et al. 1988. *Oil Windfalls: Blessing or Curse?”* Oxford University Press for the World Bank, New York.

Gollier, C. 2006. “An Evaluation of the Stern’s Report on the Economics of Climate Change.” Http://idei.fr/doc/wp/2006/stern.pdf.

Harrison, Mark. 2010. “Valuing the Future: the Social Discount Rate in Cost-Benefit Analysis.” Visiting Researcher Paper, April 2010, Productivity Commission, Australian Government. Available at http://www.pc.gov.au/employment/researcher.

HM Treasury. 2003. *The Green Book: Appraisal and Evaluation in Central Government,* Treasury Guidance. London.

Hotelling, Harold. 1931. “The Economics of Exhaustible Resources.” *Journal of Political Economy* 39(2): 137-75.

IDA (International Development Association) and IMF (International Monetary Fund). 2013. “Niger - Joint IMF/IDA Debt Sustainability Update.” Washington, DC: The World Bank.

IMF Country Report No. 12/109, Niger, May 2012.

Lofgren, Hans, Martin Cicowiez, and Carolina Diaz-Bonilla. 2013. “MAMS: An Economy-wide Model for Development Strategy Analysis.” In Peter Dixon and Dale Jorgenson, eds., *Handbook of Computable General Equilibrium Modeling*. Amsterdam: North Holland Publications.

Lofgren, Hans, James Thurlow and Sherman Robinson. 2004. “Prospects for Growth and Poverty-Reduction in Zambia, 2001-2015”, IFPRI report to World Bank (CEM).

Mehlum, H., K. Moene, and R. Torvi. 2006. “Insitutions and the Resource Curse.” *Economic Journal*, Vol. 116, No. 508, pp. 1-20.

Nordhaus, W. 2007. "A Review of the Stern Review on the Economics of Climate Change." *Journal of Economic Literature*, vol.XLV, September, pp. 686-702.

Robinson, Sherman, and James Thurlow. 2004. A Recursive Dynamic Computable General Equilibrium (CGE) Model: Extending the Standard IFPRI Static Model. Photocopy. Washington,DC: International Food Policy Research Institute.

Sachs, J. and A. Warner. 1997. "Natural Resource Abundance and Economic Growth." In G. Meier and J. Rauch, eds. *Leading Issues in Economic Development.* , Oxford, Oxford University Press.

Schmidt-Hebbel, Klaus. 2012. "Fiscal Policy for Commodity-Exporting Countries: Chile's Experience." In Arezki, Rabah, Catherine Pattillo, Mark Quintyn, and Min Zhu, Eds., pp. 105-146.

Stern, Nicholas. 2007. *The Economics of Climate Change: The Stern Review.* Cabinet Office – HM Treasury, Cambridge University Press, UK.

Turnovsky, Stephen J. 1997. "Private and Public Capital in an Endogenously Growing Economy." Journal of Public Economics 60(1): 21-44.

UN (United Nations). 2009. *National Accounts Statistics: Main Aggregates and Detailed Tables, 2009.* New York: United Nations.

van der Ploeg, Frederick. 2011. "Natural Resources: Curse or Blessing?" *Journal of Economic Literature* 49(2): 366-420.

van der Ploeg, Frederick. 2010. "Aggressive Oil Extraction and Precautionary Saving: Coping with Volatility." *Journal of Public Economics* 94 (2010): 421-33.

van der Ploeg, Frederick and Anthony J. Venables. 2011. *The Economic Journal*, 121 (March): 1-30.

van Wijnbergen, Sweder J.G. 1984. "The 'Dutch Disease': A Disease after All?" Economic Journal , 94(373):41-55.

Weitzman, M. 2007. "A Review of the Stern Review on the Economics of Climate Change." *Journal of Economic Literature*, vol.XLV, September, pp. 703-24.

Zhuang, J., Z. Liang, T. Lin, and F. de Guzman. 2007. "Theory and Practice in the Choice of Social Discount Rate for Cost-Benefit Analysis: A Survey." ERD Working Paper 94, Asia Development Bank, May.