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Natural-Resource Depletion, Habit Formation, and Sustainable Fiscal Policy: Lessons from Gabon

Daniel Leigh and Jan-Peter Olters

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Prepared by Daniel Leigh and Jan-Peter Olters

Authorized for distribution by Manmohan Kumar and Roger Nord

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Abstract

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While models based on Friedman's (1957) permanent-income hypothesis can provide oilproducing countries with long-run fiscal targets, they usually abstract from short-run costs associated with consolidation. This paper proposes a model that takes such adjustment costs (or "habits") into account. Further operational realism is added by permitting differential interest rates on sovereign debt and financial assets. The approach is applied to Gabon, where oil reserves are expected to be exhausted in 30 years. The results suggest that Gabon's current fiscal-policy stance cannot be maintained, while the presence of habits justifies smoothing the bulk of the adjustment toward the sustainable level over three to five years.

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Author(s) E-Mail Address: dleigh@imf.org and jolters@imf.org

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I. INTRODUCTION

A combination of *overall* fiscal surpluses and *non-oil* deficits characterizes the budgets of major oil-producing countries when petroleum prices are high. If exploitable reserves are sufficiently abundant, large non-oil deficits do not pose immediate vulnerability and sustainability concerns. However, when oil fields are mature and reserves declining, it may prove impossible to maintain a given level of non-oil deficits, necessitating governments to adjust their fiscal policy stance. For oil-producing economies, large (but exhaustible) oil revenues often create the illusion that binding budget constraints have disappeared. Abundant government resources inevitably generate political pressures to spend a larger portion of current income than could be maintained beyond the period of oil production. In addition, excessive spending creates dependencies and vested interests, implying that governments face the added challenge of justifying fiscal consolidation while overall fiscal balances are in surplus.

In this context, policymakers would benefit from a clear benchmark against which to judge the implementation of fiscal policy and assess the degree of fiscal consolidation that would be required for sustainability reasons. Such a fiscal anchor provides the legislative branch (and the electorate) with a yardstick to distinguish sound and forward-looking fiscal policies from short-sighted ones designed to address only immediate demands. Ideally, such a framework would be established at the start of oil production, before habits are formed, and prevent the need for a large and sudden contraction when oil revenues are exhausted. Conscious of the socioeconomic consequences of decades of boom-and-bust cycles, there is an increasing understanding among governments of established oil exporters, including Gabon's, that the pursuit of sustainable fiscal policies constitutes a central policy objective.

While existing models based on Friedman's (1957) permanent income hypothesis (PIH) can estimate appropriate long-run fiscal targets, they tend to abstract from short-run social and political costs associated with the adjustment toward that level. An abrupt, one-time fiscal consolidation followed by a constant expenditure path (equal to the expected annuity value of oil wealth and non-oil revenue) is the canonical policy recommendation. Political reality often precludes such a radical approach, however. A gradual adjustment is preferable because it takes pain away from households and policymakers alike, increasing the political acceptability of the needed reform.

Against this background, the following paper proposes a quantitative model that takes into account these types of short-run adjustment costs, while providing fiscal policy with targets that are anchored in long-run sustainability. Applying the framework, the authors seek to estimate Gabon's non-oil primary deficit that can be maintained after oil revenue runs out and to describe the optimal adjustment path toward this level. In line with the literature, this path is defined as the one that a social planner would choose. Introducing "habits"—i.e., the general notion that consumers become used to the level of consumption enjoyed in previous periods, including the consumption of public goods and services—is important in the context of fiscal policy design because it directly links the social, political, and institutional

constraints to the speed of fiscal adjustment. Allowing for different interest rates on debt and assets introduces further realism into the analysis of optimal fiscal policy and debt management.

Three main conclusions emerge from the analysis. First, Gabon's current fiscal policy stance cannot be maintained. Second, due to habit formation, the optimal policy spreads the bulk of the adjustment over three to five years, rather than requiring a single correction that standard permanent income models would prescribe. Third, the interest rate differential between sovereign debt and financial assets creates an incentive for front-loading adjustment and paying off debt sooner than in the absence of the spread. This argument for front-loading adjustment is reinforced by precautionary considerations stemming from uncertainty regarding future economic conditions.

The remainder of the paper is structured as follows. Section II provides the background and surveys the relevant literature. Section III describes the analytical framework and calibrates the model to fit Gabon's economy. On that basis, Section IV estimates the permanently sustainable fiscal deficit and simulates the optimal adjustment path toward this level. Section V discusses extensions to the analysis, while Section VI summarizes the results and offers conclusions.

II. BACKGROUND

A. Transferring Wealth Before Oil Reserves Are Depleted

In recent years, emerging oil exporters have demonstrated considerable commitment to devising institutional arrangements that limit fiscal discretion over oil revenue.² The creation of fiscal reserves—or, equivalently, the definition of rules over the use of oil revenue—are meant to preclude governments from repeating the mistakes made by many of the more mature oil-exporters, including Gabon, and from having them form difficult-to-reverse spending habits. Contrary to previous generations of oil-fund arrangements (Davis and others, 2001), many of the most recent ones are explicitly based on the premise that all income from oil production is inherently different from other revenue streams (see, e.g., Azerbaijan, Mauretania, São Tomé and Príncipe, or Timor-Leste), requiring governments to justify their spending plans out of these temporary revenue streams vis-à-vis the legislature and the broader public (Table 1).

The pattern of public spending in Gabon over the past three decades suggests that governments have abstracted from the finite nature of oil reserves and treated related

² See Danninger and others (2004) for Azerbaijan, Kim (2005) for Timor-Leste, Lohmus (2005) for Kazakhstan, and Segura (2006) for São Tomé and Príncipe.

Table 1. Emerging Oil Exporters: Limits to Fiscal Discretion over Oil Revenues

	Year	Institutional Arrangements for Wealth Preservation	Fiscal Rules for Oil Revenues
Gabon	1998	Law establishing <i>Fonds pour les générations futures</i> (not implemented)	<i>Budgeted oil revenues:</i> 10% if FGF < CFAF 500 billion, 25% of FGF revenue if FGF > CFAF 500 billion. <i>Windfall oil revenues:</i> 50% if FGF < CFAF 500 billion, 100% if FGF > CFAF 500 billion.
Emerging oil exporters			
Azerbaijan	1999	<i>State Oil Fund</i> (SOFAZ)	100% into SOFAZ. Oil fund rules prohibit spending in excess of inflows in any given year.
Mauretania	...	<i>National Hydrocarbon Revenue Fund</i> , Treasury account managed by central bank (not yet fully operational)	100% into revenue fund. Annual budget law defines maximum amount that can be withdrawn each year.
São Tomé and Príncipe	2004	<i>National Oil Account</i> , with sub-account (<i>Permanent Fund</i>)	100% into oil account. Withdrawal for PRSP expenditure equal to the interest income on the NPV of oil wealth.
Timor-Leste	2005	<i>Petroleum Fund</i>	100% into petroleum fund. Procedural guidelines allow expenditure to exceed sustainable level if authorized by Parliament.

Source: Gabonese authorities; various IMF documents.

revenues analogously to tax receipts collected from non-oil activities.³ Consequently, they engaged in large-scale projects with high recurrent-cost implications. In years of declining international oil prices, these costs exceeded available budget resources, necessitating dramatic fiscal adjustments. As a result, Gabon experienced severe boom-and-bust cycles (Figure 1), which contributed to a legacy of stalled socioeconomic development, substandard and ill-maintained public infrastructure, a high degree of public indebtedness, and an uncompetitive non-oil sector.

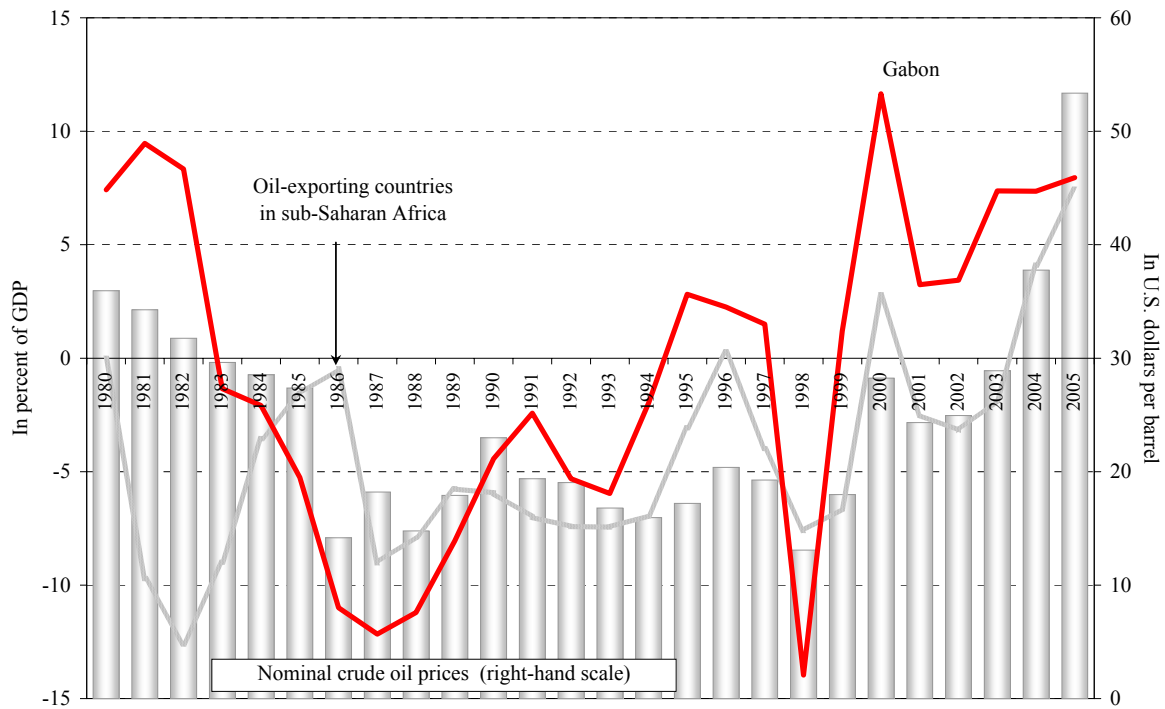
Recently, however, this process of fiscal policy formulation has been reexamined.⁴ Against the backdrop of gradually diminishing reserves, Gabon is beginning to recognize the importance of devising fiscal policies that are sustainable over the long term and consistent with its economy's absorptive capacity. For political-economy reasons, however, the government has found it very difficult to overcome entrenched addictions to government largesse. Yet, in the absence of new discoveries, Gabon is under pressure to take action. While being accustomed to large oil revenues, the authorities face the specter of dry wells and, *pari passu*, the choice between initiating a voluntary, gradual policy adjustment toward a sustainable fiscal policy stance or a temporary delay in making politically difficult decisions,

³ For a discussion of public finance in Gabon during the early decades of oil production, see Barro Chambrier (1990), de Mowbray (1991), and Yates (1996).

⁴ In early 2006, the Government of Gabon (2006) has approved a Growth and Poverty-Reduction Strategy Paper (PRSP) that, in addressing principal obstacles to socioeconomic development, explicitly acknowledges related challenges.

thereby postponing the adjustment until depleted oil reserves (or unexpectedly falling oil prices) force the authorities to contract public spending abruptly and accept a permanently lower standard of living.

Figure 1. Overall Fiscal Balance and International Oil Price, 1980–2005



Source: IMF, African Department, *Regional Economic Outlook 2005*.

Following the economic crisis of 1998, Gabon had introduced a number of institutional changes, notably the establishment of a *Fonds pour les générations futures* (FGF) with corresponding fiscal rules. A number of these rules, however, have not been implemented (Box 1). This episode highlights the considerable difficulty in designing fiscal policies over a long-term horizon—spanning over a life cycle beyond that of any given government—without having defined an appropriate fiscal anchor of the type proposed in this paper. More recently, further attempts were made to put fiscal policies on a sounder basis, but there has not been a consistent approach to formulating fiscal policy and reserve management. The PRSP—representing a second, more broadly based attempt at reorienting fiscal policies in Gabon—places the socioeconomic development strategy into a macro-fiscal framework that explicitly recognizes the benefits of maintaining macroeconomic stability.⁵

⁵ To be able to motivate politically the fiscal adjustment in periods of high oil prices, this link is important. Previous experience has shown that the economic costs stemming from the bursting of oil booms was borne disproportionately by the most disadvantaged segments of society; see, e.g., World Bank (1997).

Box 1. Gabon's Fund for Future Generations

The law. In mid-1998, Gabon established a *Fonds pour les générations futures* (FGF) and defined fiscal rules that were to guarantee the accumulation of fiscal reserves. Law No. 9/98 defined a minimum FGF capital of CFAF 500 billion (Art. 2), off-limit to the government even in exceptional circumstances or as a source of collateral (Art. 3). The assets were to be invested in stocks of companies with international reputation and low-risk financial instruments (Art. 6). Only during a transition period up until end-1998, the budget was to contribute an exceptional endowment, which the regional central bank was to manage in a special account (Art. 14).

Implementation. The transitional stipulations have been applied also in the following years, with FGF funds being held by the *Banque des Etats de l'Afrique centrale* (BEAC) and remunerated in line with other "special accounts." Recently, these have been gradually increased from 1.6 percent at end-2005 to 1.9 percent in March 2006 and—by creating a special category of fiscal reserves for future generations (cf. BEAC Decision No. 09/GR/2006)—to 2.2 percent in June 2006. Contributions by the budget to the FGF were sporadic, and—in violation of the FGF law—capital was withdrawn in 2003. By end-2005, the budget contributed CFAF 84 billion to the FGF, representing 8.8 percent of the amount that would have been saved had the law been respected fully. During the same period of time, however, the authorities significantly reduced their stock of public debt, including arrears. Given that Gabon's debt carries an interest rate far in excess of the FGF interest rate, the government's realized net savings were probably a more rational strategy of reserve management, even though they were more erratic than what the FGF law implied and represented only about 60 percent of the implicit total asset accumulation vis-à-vis the oil fund.

Gabon: Accumulating Fiscal Reserves, 1999–2005
(In billions of CFA francs, unless otherwise indicated)

	1999	2000	2001	2002	2003			2004	2005
					Art. 4 ¹	Art. 5 ¹	Total		
Oil revenue	368.6	814.7	752.9	609.0	571.3	12.6	583.9	628.2	907.2
Budgeted oil revenue	310.0	699.3	760.1	510.0	438.4	9.7	448.1	473.1	608.9
Windfall oil revenue	58.6	115.4	0.0	99.0	132.9	2.9	135.8	155.1	298.3
Payment into the FGF, as per law	60.3	127.7	76.0	100.5	110.3	2.9	113.2	155.1	298.3
Budgeted oil revenue	31.0	69.9	76.0	51.0	43.8	0.0	43.8	0.0	0.0
Windfall oil revenue	29.3	57.7	0.0	49.5	66.4	2.9	69.4	155.1	298.3
BEAC interest rate; in percent	3.1	3.4	3.4	3.4	2.0	2.0	2.0	2.0	1.7
BEAC interest payments, consistent with the law	...	2.1	6.5	9.4	7.3	0.2	7.5	9.8	10.9
FGF assets, consistent with the law	60.3	190.0	272.6	382.4	500.0	503.0	503.0	660.5	961.5
Actual FGF assets	...	...	...	70.4	...	...	30.0	55.0	84.3
In percent of hypothetical FGF assets	...	...	...	18.4	...	...	6.0	8.3	8.8

Source: Gabonese authorities; and Fund staff estimates.

¹ Articles 4 and 5 of Law No. 9/98 of July 16, 1998, establishing the FGF, refer to the fiscal rules before/after having accumulated the minimum capital of CFAF 500 billion.

B. Lifting the Natural-Resource Curse

Since the mid-1990s, when oil prices were low, an extensive literature has developed that analyzed the reasons behind the considerable difficulty that a large number of oil-producing countries encountered in formulating fiscal policies that would effectively transform natural-resource wealth into other forms of capital. Economic history is littered with examples of lackluster growth and incidences of boom-and-bust cycles. These episodes, of course, have regularly reminded affected authorities of their deficiencies in fostering and developing non-oil activities while resources were available. In fact, fiscal crises caused by falling oil prices or depleting reserves have tended to inflict long-term damage to the economies, with disproportionate effects on the poorest households.

With inconsistent policies, the trend growth rates in countries generously endowed with natural resources have generally been disappointing. Economists having subsumed these “empirical regularities” (Hausmann and Rigobon, 2003) under the heading of the “natural-resource curse”⁶—a phenomenon that is typically explained as the result of increased rent-seeking behavior, reduced incentives for necessary economic reforms, and excessive borrowing. In the absence of responsive policies, the macroeconomic effects of a temporary exploitation of natural resources include the real appreciation of the domestic currency, leading, as discussed by Corden and Neary (1982), to a country’s loss of international competitiveness and a gradual process of deindustrialization (“Dutch disease”).

Gabon’s economy as well has exhibited symptoms of the natural-resource curse—as evidenced by the long-run anemia in non-oil growth rates and the near absence of exports other than natural resources.⁷ A number of authors have pointed to the fragility of Gabon’s non-oil sectors, an overly generous public sector, and the inherently adverse debt dynamics (Barro Chambrier, 1990). More recently, formal models have been proposed by Ntamatungiro (2004) and Söderling (2005) that demonstrate the need for establishing a more sustainable fiscal path in Gabon.

Pursuing sustainable fiscal policies in periods of high oil revenues is particularly difficult in countries with a fragile public infrastructure and weak social indicators, making policymakers even more susceptible to political pressures for higher spending. As Collier and Gunning (2005) argued, the core problem of a government in an oil-rich country—assuming that socioeconomic development is the underlying policy objective—consists of finding ways to crowd in private sector investments, while taking into consideration the constraints

⁶ This term has been coined by Auty (1993) and Sachs and Warner (1995). In a recent study, Mehlum, Moene, and Torvik (2006) argue that the quality of public institutions determines whether or not resource-rich countries avoid the natural-resource curse.

⁷ During 2002–05, exports of oil, wood, and manganese averaged close to 97 percent of total exports.

imposed on policymakers by the economy's limited absorptive capacity and inadequate policy instruments. For these reasons, they view—under those circumstances—the reduction of (domestic) debt as the most effective way of using oil windfalls.

In so doing, Collier and Gunning point to the most critical question—namely, the one on the most effective use of oil (windfall) revenues. Is it really the best advice to orient fiscal policies toward fiscal-sustainability objectives? Does it not neglect the possibility that wealth is more effectively transferred to future generations by investing current oil revenue into public investments that facilitate private sector activities and accelerate non-oil growth? This argument has been most elegantly addressed by Takizawa, Gardner, and Ueda (2004), who wonder whether developing countries would not be better off spending their oil wealth upfront. Accordingly, they model government spending not only as consumption, as done in standard permanent-income-type models,⁸ but as the sum of recurrent and capital expenditure. On the basis of their simulations, Takizawa and others (2004, page 19) show that,

“when the initial capital stock is low, the model validates the intuition that the country can be better off spending more of its oil wealth upfront, if government spending has positive externalities in production. In as much as government spending increases the return to private investment, it helps accelerate convergence to steady-state growth.”

As such, their paper represents an important contribution toward developing a more comprehensive conceptual framework, within which governments—in transforming oil wealth into alternative forms of capital—do not necessarily smooth consumption over time but attempt to maximize national wealth. However, as argued by other authors, their model reinforces the crucial importance of good governance and strong public institutions (page 19):

“when the efficiency of government spending increases over time, as it well might in developing countries that suffer not only from poor infrastructure but also from weak institutions, there are greater advantages to postponing spending to when it can be used more effectively.”

This result implies the following: only if a country takes effective measures to improve governance, strengthen public institutions, and develop clear procedures with which to design sectoral and overall investment strategies, transparently implement these and subject the projects to consistent quality controls, the question will become relevant whether public investment should be scaled up.

⁸ Models developed in this vein typically argue that the optimal design of fiscal policies in countries endowed with large, exhaustible natural resources entails saving a large part of the oil windfall revenues; see Barnett and Ossowski (2003), as well as various countries studies; see Davoodi (2002) for Kazakhstan, Baunsgaard (2003) for Nigeria, Wakeman-Linn and others (2004) for Azerbaijan, and Velculescu and Rizavi (2005) for Trinidad and Tobago.

In Gabon, programs to strengthen public institutions and provide essential public services have—so far—been poorly executed. Melhado (2006) points to such a policy outcome, in which substandard public infrastructure and poor social indicators, which are more in line with those of low-income countries in sub-Saharan Africa, belie Gabon's status as a middle-income country. This unflattering juxtaposition of high income and low development is also reflected in the situation of other oil-exporters with similar per capita income,⁹—namely, Kazakhstan, the Islamic Republic of Iran, and Algeria. The latest United Nations Development Programme (UNDP, 2005) *Human Development Index*, for instance, is considerably lower for these oil exporters than that of comparable countries without natural-resource endowments (Table 2).

Table 2. Oil Production and Socioeconomic Development

	Per Capita GDP US\$ PPP ¹ 2003	Country Indices		Remaining Oil Reserves ⁴ (bbl/person)	Non-Oil Revenue ⁵ 2004	Primary Non- Oil Deficit ⁵ 2004
		Human Development ¹	Corruption Perception ²			
<i>Countries with a per capita income of US\$6,400 ± US\$600</i>						
Oil-producing countries³	6,543	0.714	2.8	2,358	18.8	17.2
Kazakhstan	6,671	0.761	2.6	2,668	17.9	4.8
Iran, Islamic Republic of	6,995	0.736	2.9	4,721	15.9	25.7
Algeria	6,107	0.722	2.8	365	16.9	30.5
Gabon	6,397	0.635	2.9	1,680	24.3	7.7
Non-oil producing countries	6,420	0.762	3.3	...	28.9	-0.5
Tonga	6,992	0.810	...	...	...	...
Panama	6,854	0.804	3.5	...	16.9	-2.3
Macedonia	6,794	0.797	2.7	...	37.5	-1.6
Belarus	6,052	0.786	2.6	...	35.3	-0.1
Bosnia and Herzegovina	5,967	0.786	2.9	...	48.9	1.5
Colombia	6,702	0.785	4.0	...	15.6	1.6
Samoa (Western)	5,854	0.776	...	...	...	...
St. Vincent and the Grenadines	6,123	0.755	...	...	...	...
Belize	6,950	0.753	3.7	...	22.3	0.6
Fiji	5,880	0.752	4.0	...	...	...
Turkey	6,772	0.750	3.5	...	24.5	-5.1
Dominican Republic	6,823	0.749	3.0	...	...	...
Turkmenistan	5,938	0.738	1.8	...	...	...
Namibia	6,180	0.627	4.3	...	30.4	1.3

¹ Source: UNDP, 2005, *Human Development Report 2005*, pp. 219-22.

² Index between 10 (least corrupt) and 0 (most corrupt). Source: Transparency International, 2005, *Corruption Perceptions Index 2005*.

³ Countries with fiscal petroleum revenue accounting for at least 20 percent of total fiscal revenue in 2004.

⁴ Excluding natural gas. Source: BP Statistical Review, end-2004 (www.eia.doe.gov/emcu/international/reserves/xls) and IMF, *IFS Yearbook 2005*.

⁵ In percent of non-oil GDP. Sources: Various IMF reports. Fiscal data for Panama are 2002.

⁹ US\$6,400 ± US\$600 in purchasing power parity (PPP) terms. Note that Gabon's per capita gross national income (GNI), on a PPP basis, is substantially lower than its GDP per capita on a PPP basis, because a large share of private oil companies' profits are remitted abroad. For example, the World Bank's *World Development Indicators* report a GDP per capita for Gabon of US\$6,717 in 2004, on a PPP basis, as compared to a GNI per capita of US\$5,600 in 2004, also on a PPP basis.

The four oil exporters' average index of 0.714, which would rank them 108th (out of 177 countries), is considerably lower than the 0.762 value (equivalent to the 79th rank) of those countries that are not endowed with oil resources. Within this group, Gabon ranks last, with an index equal to 0.635 (123rd). Increasing rent-seeking behavior could be one explanation: the corruption perception index compiled by Transparency International (2005) shows that oil exporters average a value of 2.8, equivalent to the 97th rank out of 158 countries, or 20 places below the other countries in the same income group. These indices corroborate empirical findings that have identified weak governance as an important explanatory variable for the slow growth of resource-rich economies (Leite and Weidmann, 1999).

III. THEORETICAL FRAMEWORK

Intertemporal optimization with habit formation lies at the core of the paper's analysis. The section starts by describing the standard permanent income hypothesis (PIH) model (Friedman, 1957) to analyze fiscal sustainability in countries with finite oil reserves. Once the model has been explained and solved, it is shown how the optimal fiscal policy changes with the introduction of habits.

According to the PIH, agents are forward-looking and optimal policy is defined as a path of government spending that smoothes consumption over time and is consistent with the intertemporal budget constraint. The optimal spending level depends on a number of factors, among them the future path of oil and non-oil tax revenues and the real interest rate. In the model, the government chooses an expenditure policy that maximizes a social welfare function subject to an intertemporal budget constraint and a transversality condition.¹⁰

A. The Model

Allowing the government to choose both the tax rate and the spending level is equivalent to rewriting the problem in terms of the primary deficit, as explained by Barnett and Ossowski (2003). The problem, then, can be solved in a two stage process: (i) an intertemporal decision (determining the size of the primary deficit); and (ii) an intratemporal one (determining the optimal allocation of the given deficit between spending and taxes, where the marginal benefit of spending equals the marginal cost of taxation). Since this paper focuses on intertemporal sustainability, the problem is expressed solely in terms of spending, treating the tax rate as exogenous. The government's problem can thus be written as follows:¹¹

¹⁰ For details on the theoretical and empirical difficulties surrounding the concept of a social welfare function, see Olters (2004) and the literature cited therein.

¹¹ The notation here follows Barnett and Ossowski (2003).

$$\begin{aligned}
(1) \quad & \max_{\{G_s\}} \sum_{s=t}^{\infty} \beta^{s-t} \cdot U(G_s), \\
(2) \quad & \text{s.t.} \quad B_t = R \cdot B_{t-1} + G_t - T_t - Z_t, \text{ and} \\
(3) \quad & \lim_{s \rightarrow \infty} B_{t+s} = 0,
\end{aligned}$$

where B_t is government debt at the end of period t ; $R = 1 + r$, with r being the long-run interest rate (assumed to be constant); and G_t the level of primary government expenditure. As the low quality of public investment in Gabon gives capital expenditure the characteristic of recurrent expenditure, this paper—for the reasons stated above—treats all primary government expenditure as consumption and develops a model in which households derive utility from all government spending, even when it does not increase productivity. Non-oil revenue is denoted by T_t , oil revenue by Z_t . The discount factor is $\beta = (1 + \delta)^{-1} < 1$, where δ is the rate of time preference (the degree of impatience). It is assumed that there is no uncertainty about the future.

First, a solution is obtained based on the assumption of constant non-oil GDP. The government's problem yields a solution in the form of the following Euler equation:

$$(4) \quad U^G(G_t) = \beta \cdot R \cdot U^G(G_{t+1}),$$

where $U^G(G_t)$ denotes the marginal utility of spending in period t . Assuming that $\beta \cdot R = 1$ (or, equivalently, $\delta = r$),¹² it follows that $U^G(G_t) = U^G(G_{t+1})$. This implies that government spending is constant: $G_t = G_{t+1} = G$. Combining equation (4) with equations (2) and (3) yields the optimal level of government spending:

$$(5) \quad G^* = T + \frac{r}{R} \cdot \sum_{s=t}^N \left(\frac{1}{R} \right)^{s-t} \cdot Z_s - r \cdot B_{t-1},$$

where N is the date at which oil revenue dries up. Equation (5) implies that the optimal policy is to set spending equal to permanent income, i.e., to the return on the present discounted value of all future oil and non-oil revenues.

¹² Assuming either $\beta \cdot R > 1$ or $\beta \cdot R < 1$ implies that government spending either declines to zero or explodes. The conventional approach is to exclude these two possibilities and assume instead that $\beta \cdot R = 1$.

Introducing non-oil growth does not change the essential form of the solution. Non-oil GDP is now assumed to grow at rate $\gamma > 0$, i.e., $Y_{t+1} = (1 + \gamma) \cdot Y_t$. Following Barnett and Ossowski (2003) and Tersman (1991), the government's problem is expressed in terms of non-oil GDP. Therefore, $g = \frac{G}{Y}$ is the ratio of spending to non-oil GDP, and the budget constraint becomes

$$(6) \quad b_t = \frac{R}{1 + \gamma} \cdot b_{t-1} + g_t - \tau_t - z_t,$$

where τ denotes the ratio of non-oil revenue to non-oil GDP, and z and b the ratios to non-oil GDP of oil revenue and debt, respectively. Utility is also expressed in terms of non-oil GDP terms, so that $U = U(g)$. The standard assumption that the interest rate is higher than the non-oil growth rate ($r > \gamma$) is imposed to keep the sustainability question interesting.¹³

Solving the model with non-oil growth implies a path for government spending that is analogous to the one in equation (5), i.e., a constant spending level in terms of non-oil GDP, as shown in equation (6):¹⁴

$$(7) \quad g^* = \tau + \frac{r - \gamma}{R} \cdot \sum_{s=t}^N \left(\frac{1 + \gamma}{R} \right)^{-(s-t)} \cdot z_s - \frac{r - \gamma}{1 + \gamma} \cdot b_{t-1}.$$

Introducing habit formation into the model has the advantage of greater realism with regard to the speed at which fiscal policy can adjust to macroeconomic shocks. Habit formation was developed in the consumption literature to capture the idea that consumption is addictive—i.e., the amount of utility derived from consumption today depends negatively on how much was consumed yesterday.¹⁵

Formally, introducing habits implies altering the utility function so that current-period utility depends not only on current spending, but also on past spending. Specifically, the utility

¹³ If the net real interest rate is negative ($r - \gamma < 0$), it is not necessary to run primary surpluses to reduce the debt-to-GDP ratio to zero.

¹⁴ A rule that would keep the absolute spending level constant would imply that the size of government (spending as a share of GDP) shrinks to zero over time. More plausibly, the rule in equation (6) implies that government size converges to 29 percent of GDP.

¹⁵ In the context of fiscal policy, habit formation can also be interpreted as reflecting institutional and political adjustment costs faced by policymakers (for instance, cutting the public-sector wage bill abruptly may not be politically feasible). Applying habit formation to fiscal policy, Velculescu (2004) shows that the optimal fiscal response to a permanent negative shock is to spread the necessary policy adjustment over a number of periods.

function becomes $U(g_t, h_t)$ rather than $U(g_t)$, where h_t represent the current stock of habits. Solving the government's problem yields Euler equation

$$(8) \quad U^g(g_t, h_t) + U^h(g_{t+1}, h_{t+1}) = R \cdot \beta \cdot [U^g(g_{t+1}, h_{t+1}) + \beta \cdot U^h(g_{t+2}, h_{t+2})],$$

where $U^g(g_t, h_t)$ denotes the marginal utility of an additional unit of spending in this period and $U^h(g_{t+1}, h_{t+1})$ the marginal utility of stronger habits in the next period (due to higher spending today). A popular formulation of habit formation in the literature is the “subtractive formulation”; see Constantinides (1990), Campbell and Cochrane (1999), and Uribe (1999):

$$(9) \quad U(g_t, h_t) = V(g_t - \alpha \cdot h_t),$$

where $\alpha \in [0, 1]$ denotes habit strength, and current-period spending, g_t , yields lower utility the stronger the habits, h_t . A simple specification of the habit stock is $h_t = g_{t-1}$, i.e., the current habit stock is simply equal to the level of spending in the previous period. Combining the Euler equation (7) with the intertemporal budget equation yields, after a number of algebraic manipulations, the following optimal path for government spending:

$$(10) \quad g_t^* = \left(1 - \frac{\alpha}{R}\right) \cdot \left[\tau + \frac{r - \gamma}{R} \cdot \sum_{s=t}^N \left(\frac{1 + \gamma}{R}\right)^{-(s-t)} \cdot z_s - \frac{r - \gamma}{1 + \gamma} \cdot b_{t-1} \right] + \frac{\alpha}{R} \cdot g_{t-1}.$$

Equation (10) shows that, with habit formation, spending is a linear combination of the last period's level and the PIH spending level. With habits, if the previous period's spending is higher than current permanent income, then current spending adjusts gradually to the permanent-income level at a rate of $(1 - \alpha)$ per period. Without habits ($\alpha = 0$), the optimal policy is to adjust abruptly to the PIH level in a single period.

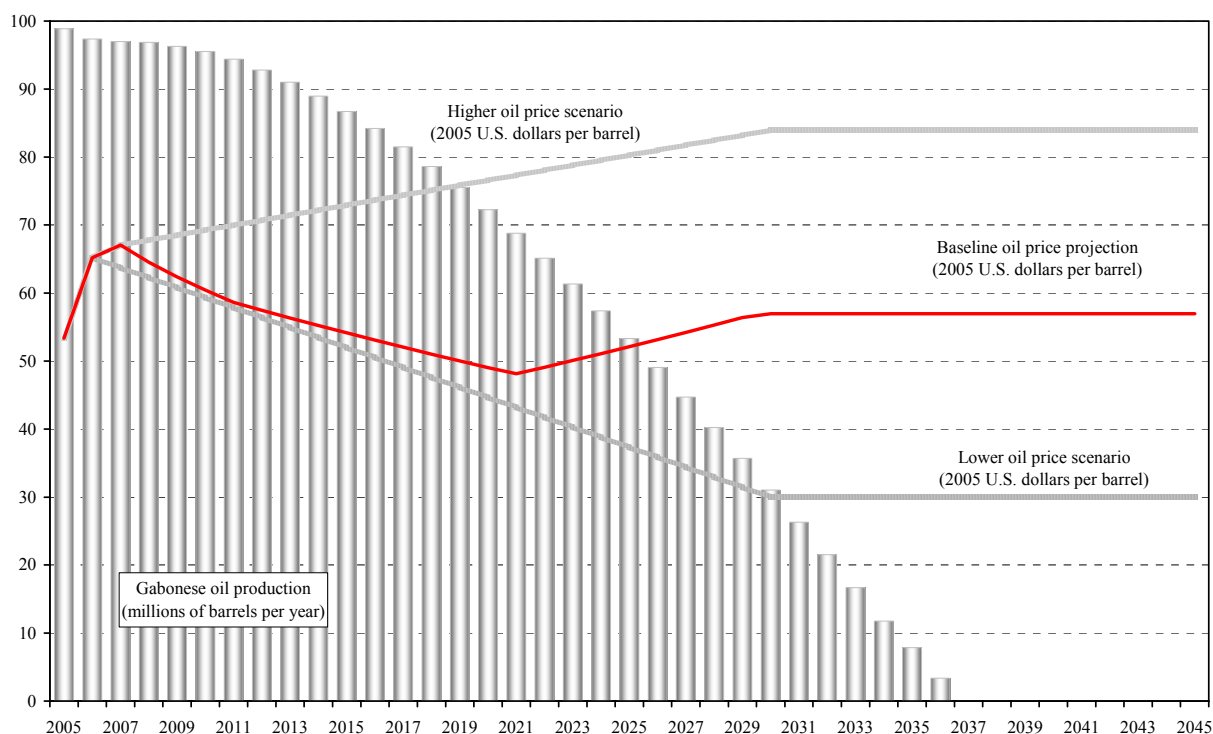
B. Model Calibration

To simulate a baseline path for adjusting fiscal policy over the medium term, this subsection calibrates the model to fit the relevant features of Gabon's economy. Once a baseline scenario is simulated, sensitivity tests are conducted on all the parameters of the model. To establish the baseline projection for future real oil revenue requires projections for the real oil price and the volume of oil production. The baseline projection for oil prices is based on the IMF's June 2006 *World Economic Outlook* (WEO) projections for 2006–11,

according to which most of the recent oil price increases are expected to be maintained in nominal terms.¹⁶

For the long-run real oil price in 2030, the source is the U.S. Energy Information Administration's (EIA, 2006) *Annual Energy Outlook 2006* (AEO), which forecasts a real oil price of US\$56.97 per barrel (bbl) in 2030.¹⁷ During 2012–20, real oil prices are forecast to decline as new fields are brought into production worldwide and, thereafter, to increase to US\$56.97 by 2030, reflecting rising costs for the development and production of oil resources; see also EIA (2006). Two alternative price paths, under which real oil prices either decline to the average 2000–05 level of US\$30/bbl by 2030 or continue to increase to US\$83.94 are also considered (Figure 2).

Figure 2. Oil Production Profile and World Oil Prices, 2005–45



¹⁶ An inflation rate of 2 percent per year is used to convert the oil prices into real terms.

¹⁷ This long-run price level is about US\$21 higher than the projected price in the EIA's (2005) *Annual Energy Outlook 2005*.

As for future oil output, Gabon is reported to have proven oil reserves of at least 2.022 billion barrels.¹⁸ In the absence of further discoveries, annual oil production is expected to decline from its current level by about one-half in twenty years and to be exhausted in about thirty years (also Figure 2).¹⁹ Multiplying the predicted production volumes by the real price path, net of the intermediate consumption (which is assumed to remain constant at the 2005 level of 9.7 percent of oil production) produces a forecast for real oil GDP. These calculations include a discount for Gabonese crude oil relative to the Brent crude price, which is also to remain constant at 5.8 percent (equivalent to the discount factor in 2004).

Exchange rate forecasts are based on the WEO projections of the U.S. dollar euro rate for 2006–11, implying a gradual appreciation from CFAF 527 per US\$1 in 2005 to CFAF 501 in 2011; afterwards, the exchange rate is held constant at CFAF 500 per US\$1. Fiscal oil revenues, as in 2005, remain at 35.9 percent of oil GDP. The non-oil tax rate is kept constant at the 2005 level of 23.9 percent. It is also assumed that the long-run real interest rate equals 3 percent, which broadly reflects the current yields of 10-year treasury bonds in industrialized countries minus inflation. While a 3 percent real interest rate is a standard value in the literature, obtaining this yield would require institutional changes to Gabon's FGF, which, as of June 2006, earns a mere 2.15 percent *nominal* rate.²⁰ The non-oil growth rate, γ , is set at 2 percent, the average of the last ten years. The habit-strength parameter, α , is set at 0.7, which is within the range of estimates in the literature.²¹ Table 3 summarizes the assumptions underpinning the baseline simulation.

¹⁸ This estimate for 2004 is reported by a number of agencies, including by the CIA's *World Factbook*. Other sources, such as the BP Statistical Review (2004), the Oil & Gas Journal (2004), or World Oil (2004), as quoted on the EIA website www.eia.doe.gov/emeu/international/oilreserves.html, have slightly higher estimates, ranging from 2.2 to 2.5 billion barrels.

¹⁹ For an analysis of the uncertainty of future oil production in Gabon, see World Bank (2006).

²⁰ Reforms that would help to raise the return on public savings could involve bringing the FGF closer in line with the Norway State Petroleum Fund, which secured an average annual real return, net of management costs, of 4.3 percent (Norges Bank, 2005).

²¹ For estimates of the habit formation parameter, see Fuhrer (2000) and Gruber (2001).

Table 3. Baseline Assumptions

Variable	Values
Total proven reserves	2.022 billion barrels
Long-run oil price	56.97 2005 U.S. dollars per barrel
Discount on Gabonese oil	5.8 percent of international price
Intermediate oil sector consumption	9.7 percent of value of oil production
Tax take on oil activities ¹	35.9 percent of oil GDP
Effective non-oil tax take ¹	23.9 percent of non-oil GDP
Total primary expenditure in 2005	36.4 percent of non-oil GDP in 2005
Total public debt in 2005	95.2 percent of non-oil GDP in 2005
Sum of all future oil revenue	711.0 percent of non-oil GDP in 2005
Real interest rate	3.0 percent
Real non-oil growth rate	2.0 percent
Habit strength	0.7

¹ These are held constant at the actual values realized in 2005.

IV. RESULTS AND SENSITIVITY TESTS

In simulating the optimal adjustment path, starting from the 2005 non-oil primary deficit level of 12.5 percent of non-oil GDP, three main results emerge:²²

First, the current level of the non-oil primary deficit is not sustainable. If the non-oil primary deficit is maintained at the 2005 level of 12.5 percent of non-oil GDP, debt will eventually explode. With baseline assumptions, the permanently sustainable non-oil primary deficit is estimated to be 5.5 percent of non-oil GDP. The result that the 2005 deficit is unsustainable is robust, based on a range of sensitivity tests on all the parameters in the model (Table 4). For example, even if total reserves were to increase by 25 percent relative to the baseline, the sustainable deficit would rise to 7.0 percent of non-oil GDP, still well below the actual 2005 level. If the authorities succeeded in raising the tax take on oil GDP by 10 percentage points to 46 percent, the sustainable non-oil primary deficit would increase to 7.4 percent of non-oil GDP, also well below the current level.

Second, the optimal path involves spreading the bulk of the adjustment over a period of three to five years. Under baseline parameters, the non-oil deficit would decline by 4.6 percentage points from 12.5 to 7.9 percent of non-oil GDP during 2005–08, which would be more than 65 percent of the total adjustment required. By 2010, the non-oil primary deficit would be equivalent to 6.7 percent of non-oil GDP, implying that 83 percent of the required adjustment would have been completed. Figure 3 shows that substantial overall primary surpluses occur during the oil period—needed to pay off debt and accumulate sufficient financial assets. From a fraction of the returns on those assets, it then finances the non-oil deficit in the post-oil period. By contrast, a strategy of stabilizing net debt at a positive level would not be consistent with running a permanent deficit in the post-oil era. As oil reserves are exhausted, the primary surpluses decline and converge to the permanently sustainable level of 5.5 percent of GDP in 2036, the year when oil revenue is assumed to dry up. The adjustment path depends, however, on the strength of habits. Figure 4 shows the optimal path for three alternative values of the habit strength parameter that are within the range of empirical estimates in the literature.

Third, given the uncertainty of future economic conditions, a risk-averse policymaker would have a strong motive for a faster adjustment, aiming for a lower long-run deficit, than is recommended under baseline assumptions. For instance, should the oil price revert to US\$30/bbl over the medium term, the permanently sustainable level would be only 4.8 percent of non-oil GDP. If the government's effective oil tax take declines by 10 percentage points to 26 percent (e.g., because production in Gabon's maturing oil fields becomes less profitable, the government might need to offer more generous production-

²² An Excel file that replicates all the simulation results presented in the paper is available upon request and can readily be adapted and applied to other countries with exhaustible energy resources.

sharing agreements to private companies), the sustainable deficit would be only 3.6 percent of non-oil GDP. The most critical assumption, with the highest downside risks, is the real interest rate. Following the literature on precautionary savings, the appropriate response of a risk-averse policymaker to greater uncertainty about future revenue would be to increase savings.²³ To insure against a deterioration in conditions, front-loading fiscal adjustment would therefore be advisable. However, neither uncertainty nor different degrees of risk aversion are formally analyzed by the model in this paper.

Table 4. Sensitivity Analysis

Variable	Notation	Value	Unit	Permanently Sustainable Non-Oil Primary Deficit Assuming a Long-Run Oil Price of		
				US\$30/bbl	US\$57/bbl	US\$84/bbl
				(Percent of non-oil GDP)		
Baseline parameters				4.8	5.5	7.6
Sensitivity tests						
Oil reserves (baseline)		100	percent			
Higher oil reserves (new discoveries)		125	percent	5.7	7.0	9.8
Lower oil reserves (uneconomic exploitation)		75	percent	3.8	4.0	5.2
Effective oil tax take (baseline)	$z =$	35.9	percent of oil GDP			
Higher oil tax take	$z =$	45.9	percent of oil GDP	6.5	7.4	10.0
Lower oil tax take	$z =$	25.9	percent of oil GDP	3.1	3.6	5.1
Non-oil tax take (baseline)	$\tau =$	23.9	percent of non-oil GDP			
Higher non-oil tax take	$\tau =$	33.9	percent of non-oil GDP	5.0	5.7	7.8
Lower non-oil tax take	$\tau =$	13.9	percent of non-oil GDP	4.6	5.3	7.3
Real interest rate (baseline)	$r =$	3.0	percent			
Higher interest rate	$r =$	3.5	percent	6.9	7.9	10.8
Lower interest rate	$r =$	2.5	percent	2.5	2.9	4.0
Real non-oil growth rate (baseline)	$\gamma =$	2.0	percent			
Higher growth rate	$\gamma =$	2.5	percent	2.5	2.9	4.0
Lower growth rate	$\gamma =$	1.5	percent	6.9	7.9	10.8
Habit strength (baseline)	$\alpha =$	0.7				
No habits	$\alpha =$	0.0		5.0	5.7	7.7
Stronger habits	$\alpha =$	0.8		4.7	5.4	7.5
Weaker habits	$\alpha =$	0.6		4.9	5.6	7.6

²³ See Deaton (1992) and Carroll (2000) for discussions of the precautionary savings motive.

Figure 3. Optimal Adjustment Path Under Baseline Assumptions, 2000–45

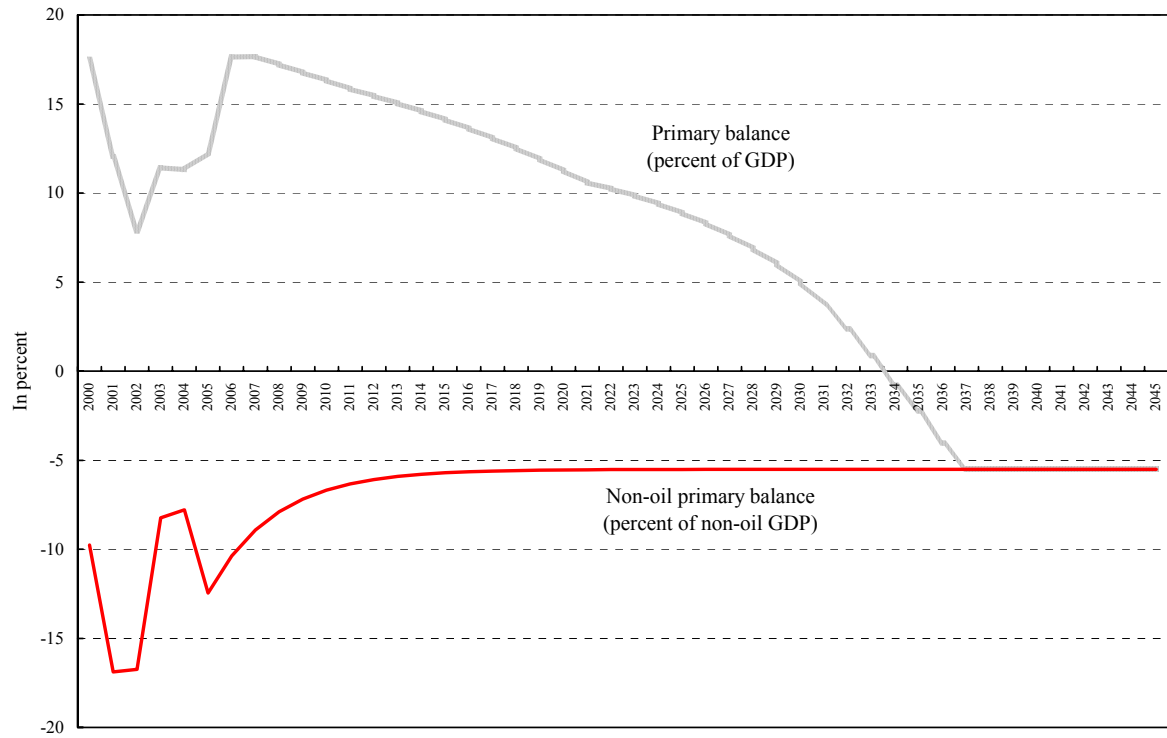
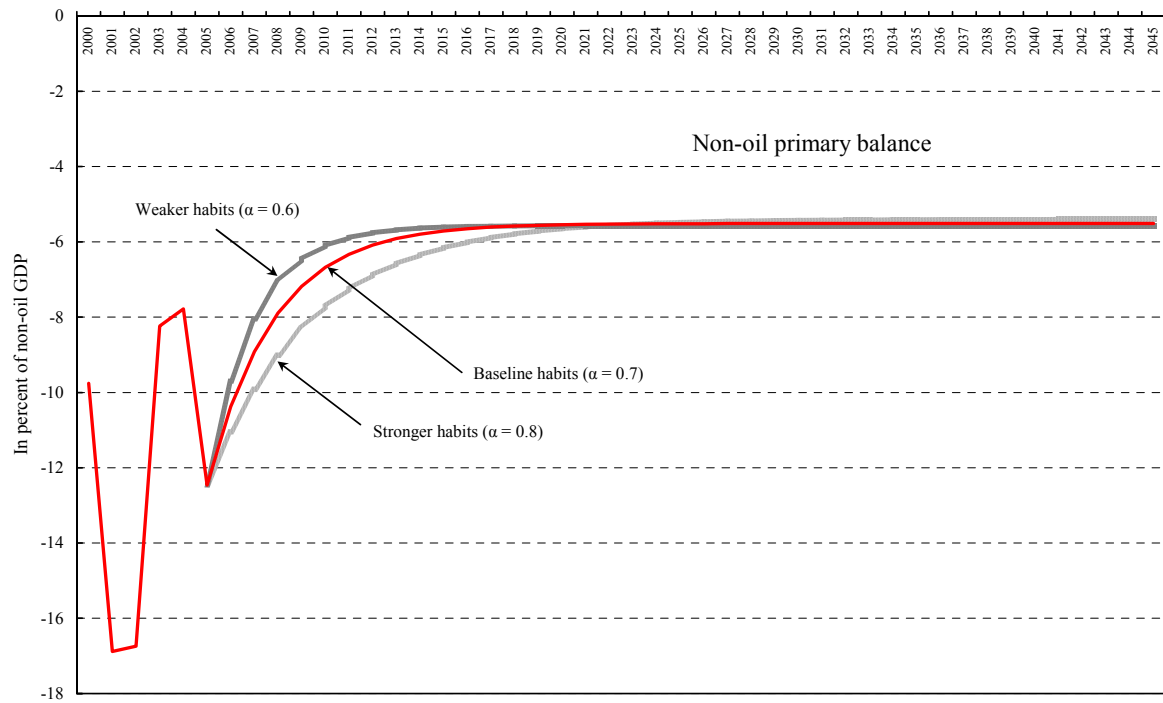


Figure 4. Sensitivity Analysis on Habit Strength and the Optimal Adjustment Path, 2000–45



V. EXTENSIONS

The speed of adjustment to a permanently sustainable primary deficit is a function of a number of additional considerations. Either including an interest-rate spread between public debt and oil-fund assets or adjusting the government's objective function to guarantee stability in real per capita expenditure would lead to an acceleration in adjustment. By contrast, relaxing the assumption of government spending being only consumption could have the opposite effect.

Introducing a spread between the interest rate on sovereign debt and the interest rate on financial assets creates a further incentive to run a smaller non-oil deficit in the short-run. The objective would be to pay off debt sooner. Formally, the solution to the government's portfolio problem now involves two first-order conditions (Barnett and Ossowski 2003). Returning, for expositional simplicity, to the simple PIH model without habits or non-oil growth, the first-order conditions become:

$$(11) \quad U^G(G_t) = \beta \cdot R^{debt} \cdot U^G(G_{t+1}), \text{ and}$$

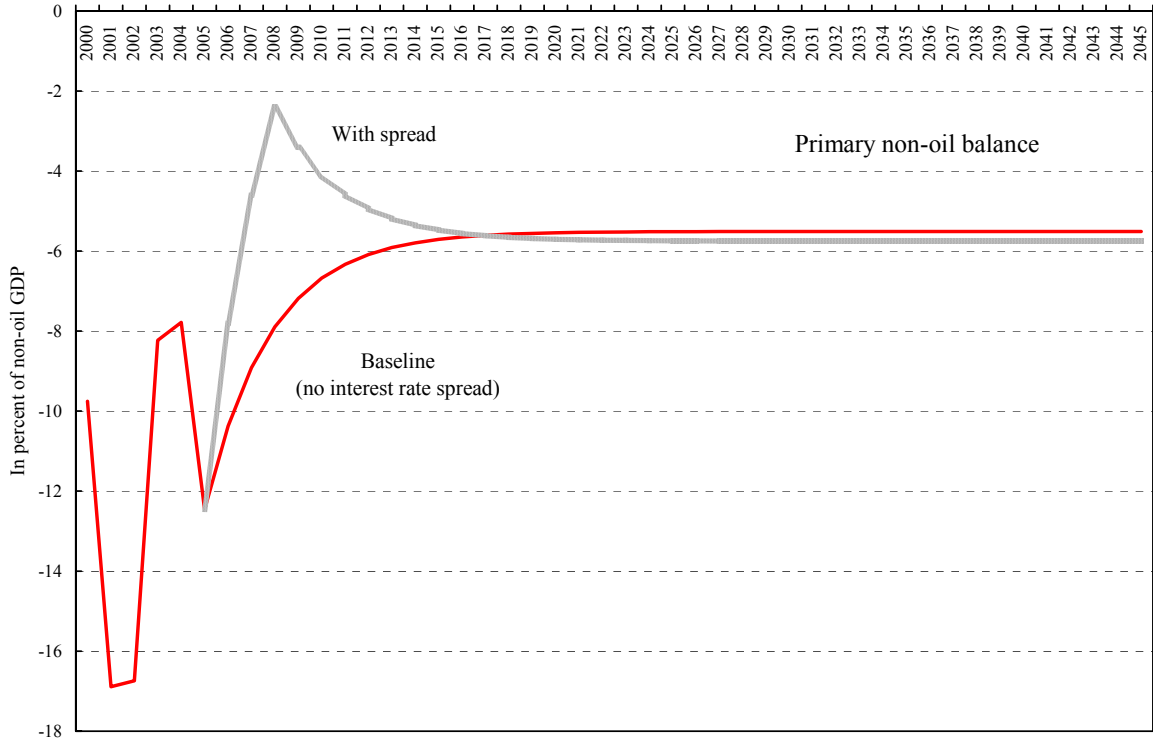
$$(12) \quad U^G(G_t) = \beta \cdot R \cdot U^G(G_{t+1}).$$

where $R^{debt} > R$, and $R = 1 + r$ is the gross interest rate on assets as before. Equation (11) holds in the initial period if there is positive debt—if $B > 0$. Since $R^{debt} > R$, and $R \cdot \beta = 1$ as before, it holds that $R^{debt} \cdot \beta > 1$ and, by implication, $G_{t+1} > G_t$. This means that government spending is increasing. Since there is debt initially, for this increasing spending to be sustainable, the initial non-oil deficit must be smaller than in the model without the interest-rate spread. Once debt has been paid off, i.e., once $B \leq 0$ and net asset accumulation begins, equation (12) holds, implying—as before—a constant path for expenditure; see equation (5).

When the interest-rate spread is incorporated into the model with non-oil growth and habit formation, the optimal adjustment path shows deficits that are smaller in the short run but larger in the long run. A simulation based on a spread of 50 basis points (Figure 5) suggests that the optimal path would include a more rapid repayment of debt—i.e., a higher degree of saving. The government would start to accumulate net assets earlier, thereby increasing the stock of financial wealth and the permanently sustainable fiscal deficit.

If the policy objective is redefined to include constant spending in real per capita terms, the adjustment must be faster. Adding population growth to the model and re-expressing the objective function in terms of spending per capita implies a lower net real interest rate (i.e., the interest rate, r , minus non-oil growth, γ , and population growth) and a lower optimal sustainable primary deficit. Intuitively, the higher the population growth rate, the more wealth will be needed to keep spending per capita constant.

Figure 5. Introducing a Debt/Asset Interest Rate Spread, 2000-45



By contrast, incorporating public investment into this model framework could imply higher fiscal deficits in the first years of fiscal adjustment. Two possible extensions of the basic Barnett-Ossowski framework have been discussed. First, if individuals derive utility from government consumption in one period and public investments over several periods, oil discoveries—increasing sustainable government consumption—would immediately increase the government’s capital stock with which to provide households a steady consumption stream. Second, if government expenditure is modeled as productive investments, it would affect the economy’s production function in periods ahead, calling for a standard portfolio decision between financial and physical (social) assets. Barnett and Ossowski’s (2003) basic condition,

$$(13) \quad r = \tau \cdot Y'(K_{t+1}),$$

states that governments—modeled in their conduct analogously to the way firms operate—should invest in all projects that will pay for themselves (irrespective of whether the country is endowed with oil reserves). This would imply that, with a tax rate of 23.9 percent and an

interest rate of 3 percent, as the simulations assume, the rate of return on public investment would have to exceed 12.6 percent.²⁴

VI. CONCLUDING REMARKS AND FUTURE RESEARCH AGENDA

In assessing Gabon's fiscal-policy options during the remaining years of oil production, this paper reaches three main conclusions. First, Gabon's current non-oil primary deficit is not sustainable. The permanently sustainable non-oil primary deficit, estimated at 5.5 percent of non-oil GDP, is well below the level of 12.5 percent of non-oil GDP in 2005. Second, the presence of habit formation implies that the optimal policy involves spreading the bulk of the adjustment over three to five years, rather than conducting the single, abrupt adjustment that standard permanent income models without habits prescribe. Third, the existence of an interest rate spread between sovereign debt and financial assets creates an incentive to front-load adjustment and to pay off net debt sooner than in the absence of a spread, increasing the permanently sustainable primary deficit. Moreover, uncertainty regarding future economic conditions would provide a risk-averse policymaker with precautionary motives for front-loading adjustment. Finally, the quality of public expenditure should improve over time as public financial management is enhanced and an appropriate growth and poverty-reduction strategy developed, providing greater assurance that government spending (including investment) could generate adequate growth and social pay-offs. An economic reform program in Gabon would therefore ideally include (i) a phased adjustment of the primary non-oil balance to a permanently sustainable level; (ii) reforms to the management of FGF assets; (iii) a rapid repayment of public debt; and (iv) structural reforms aimed at improving the design and quality of public investments.

One avenue for future research would involve relaxing the assumption, present in this paper, that government expenditure is all consumption and has no effect on productivity growth. A long-term fiscal strategy could be designed to transform Gabon's considerable oil wealth into alternative forms of wealth such as public infrastructure, social capital, and financial assets, so as to raise long-run growth. Furthermore, a richer model would allow for different rates of return on government debt, and on financial, physical, and social investment. Future work could also emphasize that some of these rates of return are partly under the control of governments (particularly when assuming that the government can take measures to ensure the maximum quality of public investments within a given expenditure envelope).

²⁴ Note that public investment can potentially yield "fiscal dividends" through three channels: (i) direct financial returns, such as tolls; (ii) fiscal returns from growth (tax revenue, provided the growing sectors can be taxed and the marginal tax rate is sufficiently high); and (iii) lower debt ratios. However, if public investment is of low quality, these "fiscal dividends" may not accrue and net debt will increase. This latter characterizes the experience of Gabon thus far.

Finally, the government's decision on the actual allocation of funds for physical and financial investments could be placed in an endogenous growth context. Here, the objective would be to solve a finite-horizon optimization problem with the government seeking to maximize national wealth. The interaction between the quality of government investment and growth in future periods would be explicitly modeled within such a framework. Optimal fiscal policy for a country that takes structural reforms to strengthen the procedures for planning and implementing public investments could then involve a larger share of oil revenues being invested in nonfinancial assets.

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