INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable solutions for ending hunger and poverty

Supported by the CGIAR

IFPRI Discussion Paper 00967

April 2010

Foreign Inflows and Growth Challenges for African Countries

An Intertemporal General Equilibrium Assessment

Xinshen Diao

Clemens Breisinger

Development Strategy and Governance Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI) was established in 1975. IFPRI is one of 15 agricultural research centers that receive principal funding from governments, private foundations, and international and regional organizations, most of which are members of the Consultative Group on International Agricultural Research (CGIAR).

FINANCIAL CONTRIBUTORS AND PARTNERS

IFPRI's research, capacity strengthening, and communications work is made possible by its financial contributors and partners. IFPRI receives its principal funding from governments, private foundations, and international and regional organizations, most of which are members of the Consultative Group on International Agricultural Research (CGIAR). IFPRI gratefully acknowledges the generous unrestricted funding from Australia, Canada, China, Finland, France, Germany, India, Ireland, Italy, Japan, Netherlands, Norway, South Africa, Sweden, Switzerland, United Kingdom, United States, and World Bank.

AUTHORS

Xinshen Diao, International Food Policy Research Institute
Senior Research Fellow, Development Strategy and Governance Division

Clemens Breisinger, International Food Policy Research Institute
Research Fellow, Development Strategy and Governance Division

Notices

[1] Effective January 2007, the Discussion Paper series within each division and the Director General's Office of IFPRI were merged into one IFPRI–wide Discussion Paper series. The new series begins with number 00689, reflecting the prior publication of 688 discussion papers within the dispersed series. The earlier series are available on IFPRI's website at http://www.ifpri.org/publications/results/taxonomy%3A468.

[2] IFPRI Discussion Papers contain preliminary material and research results. They have not been subject to formal external reviews managed by IFPRI's Publications Review Committee but have been reviewed by at least one internal and/or external reviewer. They are circulated in order to stimulate discussion and critical comment.

Contents

Abstract v

1. Introduction 1

2. A Multisector Intertemporal General Equilibrium Model for Ghana 5

3. The Dutch Disease of the Oil Boom: Short- and Medium-run Impacts on Growth and Economic Structure 9

4. Can Smart Use of Oil Revenue Mitigate Dutch Disease? 12

5. Conclusions 17

Appendix A: Supplementary Figures 18

Appendix B: Mathematical Presentation of the Multisector Intertemporal General Equilibrium Model 19

References 25

List of Tables

1. Short-run impact of oil revenue: Annual growth rate of total and sectoral GDP in the first five years under the model's base run and first oil scenarios 9
2. Non-oil sector's GDP share (total non-oil GDP = 100) 11
3. Structural effect of oil revenue inflows under different oil management scenarios (total non-oil GDP = 100) 14

List of Figures

1. Medium-run overall growth effect of oil revenue inflows 10
2. Growth effect of oil revenue inflows – investing vs. spending 13
3. Short- to medium-run effect of alternative oil management options on GDP growth 15
4. Impact of oil inflows on the level of non-oil GDP over time under the three oil management options 16

A.1. Sector shares in GDP (Ghana: 1984–2008) 18

A.2. Model calibration of GDP and agricultural GDP () 18

ABSTRACT

Foreign inflows are important sources of income that many African governments use to finance public investments and to support the development of manufacturing or export-oriented service sectors. Yet the recent growth experience of many African economies shows that domestic-oriented industry (construction, utilities) and services have become the largest sectors. Using Ghana and its newly found oil as an example, we analyze the dynamic relationship between increasing foreign inflows and economic growth and structural change by developing a multisector intertemporal general equilibrium model. We find that the sudden increase in petrodollars used to finance either the government's recurrent spending or public investment generates a substantial short-run growth shock consistent with the Dutch disease theory. Opposed short-run effects on the growth of the tradable and nontraded sectors lead the structure of the economy to become more domestic oriented. The creation of an oil fund helps reduce the negative growth and structural effect, while in the longer term, if oil spending does not enhance productivity, growth declines and the GDP share of the nontraded sector further increases. Smart use of oil revenue thus not only involves the creation of an oil fund but also spending inflows on productivity-enhancing investment. Whether public investments can help overcome Dutch disease effects also depends on the growth magnitude of the inflows. At the same level of investment-to-productivity-growth efficiency, public investments take longer to overcome the negative growth effects the higher the growth rate of inflows. This paper further shows that the structural effect of foreign inflows on economic development is a long-term challenge for Africa. The domestic-oriented economic structure can become a persistent phenomenon for countries that continue to receive foreign inflows in the form of petrodollars or in any other form.

Keywords: growth, structural change, foreign inflows, Dutch disease, Africa, Ghana, intertemporal general equilibrium

JEL classification: C68, D58, D90, F43, O11, O41, O55

1. INTRODUCTION

Low savings rates have been seen as a binding constraint to growth in low-income countries, and foreign inflows seem to be the logical and reasonable alternative source of savings to stimulate growth. Indeed, international financial flows to developing countries resumed in the 1990s and 2000s after the structural adjustment period, and globalization seems to have further stimulated the process. In the context of African countries, however, foreign inflows are mainly in the form of foreign aid, either through direct government budget support or through other types of grants provided by developed countries' governments and nongovernmental organizations. In addition, private foreign inflows to Africa have also increased. While foreign direct investment (FDI) inflows have started to play a more important role recently, remittances continue to be the main source of private foreign inflows to African countries. In Ghana, for example, remittances accounted for one-quarter of total inflows in 2007, and similar levels can be observed in many countries, such as Kenya and Ethiopia. Traditional sources of foreign exchange earnings from primary-product exports have further enhanced the upward trend in foreign inflows driven by the recent boom in prices for resource and primary agricultural products. While direct foreign borrowing is still rare, several African countries with improved macroeconomic conditions and governance increasingly have been able to gain access to international capital markets. Ghana, for example, has recently launched bonds on the London market worth US$750 million, which have been oversubscribed, with US$3 billion in offers received.

Intuitively, increased inflows should help developing countries overcome the classical growth challenge by providing additional funds for investment, particularly for public investment. When foreign inflows are efficiently invested in public goods and education, these inflows are expected to have a positive impact on growth by increasing human capital and improving the productivity of physical capital. Does growth via foreign inflows happen automatically? Recent growth experiences of developing countries and the voluminous literature on aid effectiveness and resource booms[1] have painted a mixed picture. In examining the effects of aid on growth in cross-sectional and panel data after correcting for bias, Rajan and Subramanian (2005) find little robust evidence of a positive or negative relationship between aid inflows to a country and its economic growth. Through the effect of inflows on the real exchange rate, countries with larger net inflows and more open capital accounts tend to have more overvalued currencies (Rodrik 2009a). Foreign finance has indeed relaxed the constraint of low domestic savings and led to growth in investment in Brazil, Mexico, and Turkey; however, because capital inflows are highly volatile and subject to "sudden stops," none of these countries has been able to generate consistently high growth since the end of the 1980s (Rodrik 2009b). In summary, even without taking typical institutional and governance issues related to the sudden increases in foreign inflows into consideration, foreign inflows are often associated with real exchange rate appreciation, construction booms, competition of the nontraded sector with manufacturing for scarce resources (e.g., energy), and inflation pressures from the growing demand for nontraded goods. These factors have long-run growth effects and can make it more difficult for developing countries to transform their economies by delaying the emergence of an export-oriented and labor-intensive manufacturing sector.

Against this background, this study is motivated by the potential growth and structural challenges induced by recent increases in foreign inflows to African countries. Although the macroeconomic challenges created by foreign inflows are well known, their effect on the choice of long-term development paths is less well understood. This choice of development path becomes an increasingly relevant issue for many African countries as they are striving to become middle-income countries and achieve the Millennium Development Goals. For example, it can be easily observed that prices for domestic goods and services (including urban wage rates) in African capital cities (e.g., Accra) have been much higher in recent years than in similar-size cities in Asian developing countries (e.g., Phnom Penh). This observation leads to a more fundamental development question: Can African countries develop a labor-intensive

[1] Clemens, Radelet, and Bhavnani (2004), among many other key papers, provide a comprehensive survey on this issue.

Asian-type manufacturing sector that can compete with Asian products either in the country's own domestic market or in developed countries' markets? If the next step in development for many African countries is not to develop such a manufacturing sector, what will be a suitable industrialization and development path that African countries can pursue instead?

Differences in development paths between natural-resource-rich and natural-resource-poor countries have been discussed in the development literature. By comparing different product mixes among Latin American, Asian, and Organization for Economic Cooperation and Development (OECD) countries, Leamer et al. (1999) find that Latin America exchanges natural resources and food for manufactures; Asia trades labor-intensive products for capital-intensive machinery and chemicals; and the OECD provides sophisticated manufactures and chemicals in exchange for materials, clothing, and toys. Although African countries are not included in this study, in terms of the product mix and initial conditions of resource endowments (such as land and other natural resources), one can safely position most African countries closer to Latin America than to Asia. If the initial conditions of most African countries have already prevented them from developing Asian-style labor-intensive manufacturing, increased foreign inflows (besides those from natural resource exports) can be expected to further pull these countries away from this Asian-type development path. Then the question is: What is next for African countries after the boom in foreign inflows?

The possible negative effect of foreign inflows on growth (if the institutional side effect is ignored), regardless of whether the inflows come from increased commodity prices, foreign aid, or resource booms, is Dutch disease. From this point of view, the resource-curse literature can provide additional insights. While different methodologies have been used to study the resource curse, the literature is dominated by cross-sectional growth regressions.[2] To overcome the shortcomings of this methodology, Collier and Goderis (2007) adopt a panel cointegration method to disentangle the short- and long-run effects of commodity prices on growth, and still the authors find strong evidence in support of the resource-curse hypothesis.

In addition to reduced-form growth regressions, a few structural (theoretical) models are used in explaining how resource abundance in general or resource booms in particular shift resources away from economic sectors that have positive externalities for growth. Sachs and Warner (1999), for example, develop a dynamic Dutch disease model. By constructing a sector with increasing returns to scale in an economy, together with a constant-returns-to-scale sector, the authors' Dutch disease model shows that the impact of a natural resource boom on growth depends on whether the increasing-returns sector is traded or nontraded. The possibly positive effect of a natural resource boom on growth critically depends on whether the nontraded sector has positive externalities (through increasing returns to scale) for growth. However, in reality, the manufacturing sector that is traded is often characterized by increasing returns, and thus a resource boom has a negative effect on growth by drawing resources away from the manufacturing sector. Obviously, in the theoretical model the long-run effect of foreign inflows, which can be in the form of resource boom revenues or foreign aid, depends on how the relationship between inflows and productivity growth—either through positive externalities as in Sachs and Warner (1999) or through a link to public investment, financed by the inflows—is modeled. Using a simple growth model, Rajan and Subramanian (2005) show that even under the most optimistic assumptions about the use of aid (optimistic in the sense that all aid is invested, none of it is wasted or consumed, and the Dutch disease effect on domestic price is totally ignored), the impact of aid should be positive but relatively small in magnitude. Moreover, once inflows are partially spent on nontraded goods, through the Dutch disease effect the positive public investment–productivity linkage effect on growth can be canceled out. Agénor, Bayraktar, and Aynaoui (2008) develop a dynamic macroeconomic model in which foreign aid can raise

[2] Empirical findings that resource-abundant countries tend to grow more slowly than resource-scarce countries are documented in Sachs and Warner (1995, 2001); Gylfason, Herbertsson, and Zoega (1999); Leite and Weidmann (1999); Auty (2001); Bravo-Ortega and De Gregorio (2005); and Sala-i-Martin and Subramanian (2003). Deaton and Miller (1995) and Raddatz (2007), however, find quite contrary results: Commodity booms significantly raise growth. A few studies that use panel data find that the resource-curse effect disappears once one allows for fixed effects; see, for example, Mazano and Rigobon (2006) and Murshed (2004). Van der Ploeg (2007) provides a comprehensive survey of the resource-curse literature.

public investment, which, in turn, either directly results in output growth (through accumulation of public capital) or indirectly improves productivity through human capital accumulation. The model is calibrated to the Ethiopian economy and is used to assess the growth and poverty-reduction effects of changes in the level of nonfood aid. By simulating a permanent increase in nonfood aid that is equivalent to 5 percent of gross domestic product (GDP), the model results in about 1 percentage point of additional growth in the long run. However, this model simulation outcome crucially depends on the fiscal parameters that describe the impact of aid on the tax rate, current government spending, and public investment, as well as on the efficiency assumption of public investment. Within the range of two standard-error confidence intervals, the growth effect of public investment does not necessarily mitigate the Dutch disease effect. With a higher adverse impact of aid on the tax rate and recurrent spending, and a lower positive effect on public investment, the Dutch disease effect would become more persistent, which would lead to an unsustainable external position.

While a structural approach relates empirical results to specific behavioral assumptions and parameters, the above models seem either too simple or too aggregate to explain how important a country's initial condition is in determining the effect of Dutch disease on alternative growth paths. In the simple growth model of Rajan and Subramanian (2005) and in the dynamic macroeconomic model of Agenor, Bayraktar, and Aynaoui (2008), the economy is highly aggregated (as a single output sector). Although there are two sectors, traded and nontraded, in Sachs and Warner (1999), the structure (or size) of these two sectors seems not to matter. The demand side is modeled in a very simplistic way in all these models, as is the trade relationship with the rest of world. Both factors are important in understanding how Dutch disease works through the economy in affecting resource allocation and growth. Moreover, none of the above models considers the intertemporal decision process of the private sector (consumers or producers). There is no capital, and hence the intertemporal saving and investment decisions of the private sector are not included in the simple growth model of Rajan and Subramanian (2005) or the dynamic Dutch disease model of Sachs and Warner (1999). While in Agénor, Bayraktar, and Aynaoui (2008) private capital accumulation is included, there is no behavioral function to determine such accumulation. By ignoring intertemporal behavior in the general equilibrium model, these approaches do not allow the transitional process along the growth path to be captured.

This paper fills the gap in the literature by developing a multisector intertemporal general equilibrium model in which capital accumulation is an endogenous result of the private sector's intertemporal saving/investment decisions. Dutch disease affects growth through its effect on savings and investment, in addition to its effect on relative prices. The model is calibrated to Ghana's economy in 2007, and the increase in foreign inflows is based on the newly found oil and the expected amount of oil extraction in the future. Compared with other African countries in which oil or other natural resources have been discovered in the past, current conditions in Ghana seem favorable to avoiding the resource curse caused by institutional and/or political factors. State and institution building in Ghana has made rapid progress in recent years, and some important governance indicators, including government effectiveness, regulatory quality, and control of corruption, have exceeded the regional averages of Asia, Latin America, and Africa (Kaufmann, Kraay, and Mastruzzi 2008). In terms of economic development, Ghana has experienced more than two decades of sound and persistent annual growth of around 5 percent and is among a group of very few African countries with positive per capita GDP growth over a relative long period of time. Despite this success, however, the Ghanaian economy displayed several structural characteristics typical of African countries with symptoms of Dutch disease even in the pre-oil era. Although the share of the agricultural sector in the total economy has declined over time, the sector still contributes about one-third of total GDP, which is above the African average. Also, the country's export structure has not changed much over the last 50 years. Agricultural exports are concentrated in one crop (cocoa), which, together with gold, constitutes more than 60 percent of total exports. Declines in the relative importance of agriculture as a share of GDP have been compensated by the increases in services, urban construction, and utilities. These domestic-oriented activities currently make up more than 40 percent of the economy. The manufacturing sector, which has been the main driver of growth in many Asian countries, has been declining relative to other sectors, from 9.0 percent of GDP in 2000 to 6.9

percent in 2008 (Figure A1 in Appendix). In comparison, the share of manufacturing in GDP in Vietnam, Thailand, and China rose during their rapid economic transition process and was between 15 and 37 percent when these countries had similar per capita income levels to Ghana in 2007 (Breisinger and Diao 2009).

In 2007 oil was discovered off the coast of Ghana, with total reserves estimated at between 500 million and 1.5 billion barrels and the potential for future government revenues estimated at US$1–1.5 billion annually (Osei and Domfe 2008; World Bank and IMF 2009). Measured by a modest long-term oil price of US$60 per barrel over the next 20 years, oil revenues will add around 30 percent to government income annually and constitute 10 percent of GDP over the exploitation period. Although the relative amount of expected oil revenue is smaller than in some other resource-rich countries (e.g., Angola, Botswana, and Nigeria), the expectations that additional oil revenue will help the country further accelerate growth and speed up economic transformation are high in the country.

Given the experiences of its West African neighbors and other African countries, the Government of Ghana is well aware of the potential challenge that oil could present to economic development and the still very young democratic political system. However, there is an urgent need to spend the oil revenue to address key bottlenecks in developing industrial capacities, as stated in Ghana's ambitious development plan, which aims at reaching a middle-income country status by 2015. Rather than focusing on the political economy of oil management and alternative options for oil revenue management, we use Ghana as an example to analyze the development challenge posed by increases in foreign inflows in a more general sense. The findings should be of interest not only for Ghana but also for other African developing countries that experience symptoms of Dutch disease.

In the rest of paper we first introduce the multisector intertemporal general equilibrium model in Section 2. Section 3 analyzes the short- and medium-run impacts of oil inflows on both growth and economic structure using the model. In Section 4 we assess whether smart oil management options can mitigate the Dutch disease effect by designing different oil management scenarios. Section 5 concludes the paper.

2. A MULTISECTOR INTERTEMPORAL GENERAL EQUILIBRIUM MODEL FOR GHANA

To address the research questions raised in the introduction of the paper, an analytic tool that is dynamic and incorporates multiple sectors in a general equilibrium framework is required in order to capture changes in the economic structure and the linkages between growth and the structure of the economy in the dynamic process. For this purpose, we develop a multisector intertemporal general equilibrium model for Ghana. With some modifications, this model is an extended neoclassical intertemporal general equilibrium model. Similar models have been developed by Wilcoxen (1988); Ho (1989); Goulder and Summers (1989); Go (1994); Mercenier and de Souza (1994); Diao and Yeldan (1998); Diao and Somwaru (2000); Diao and Roe (2003); and Diao, Rattsø, and Stokke (2005) for various developed and developing countries. In the context of the current study, we have made the following structural changes to the model.

We first assume a relatively closed capital market in Ghana, even though the country is an open economy in terms of trade, and commodity imports and exports are endogenously determined in the model. While FDI has come to Ghana recently (stimulated particularly by the discovery of oil), foreign inflows through private-sector borrowing from international financial markets are still limited. Thus, in the model the domestic private sector is not allowed to borrow from abroad and the only foreign inflows are remittances, foreign aid and grants, and the government's foreign borrowing. Such inflows are treated exogenously without an intertemporal decisionmaking problem.[3] The advantage of this assumption is that it allows for an endogenous interest rate measured in the domestic currency and determined by the equilibrium in the domestic capital market. The domestic capital market is modeled through the intertemporal decisions of private savings and investment. While private savings are an endogenous variable (as in any Ramsey-type intertemporal model), government savings (plus foreign inflows to finance public investment) are exogenous. In this way, the government's foreign debt is only an accounting term and will not affect the long-run equilibrium.

The second structural change in the model relates to linking public investment with productivity at the sector level. While the fundamentals of the model are consistent with the neoclassical growth theory in which productivity growth is an exogenous variable, additional public investment through increased oil revenue is assumed to have growth effects on some sectors' productivity, and hence the model can be used to quantitatively measure the impact of oil revenue management as either a short-run level effect or a long-run growth rate effect. Specifically, let

$$X_i = A_i \left(\sum_f \alpha_{i,f} \cdot (B_{i,f} v_{i,f})^{-\rho_i} \right)^{-1/\rho_i} \tag{1}$$

represent the production function for sector i, which has constant returns to scale with constant elasticity of substitution (CES) among inputs. In Equation (1), Xi is output of sector i, vi,f is a vector of inputs, A_i is the shift parameter in the production function, and $B_{i,f}$ is the level of factor productivity and is linked with public investment:

$$B_{i,f,t} = (1 + g_f + g_{i,t}^p) \cdot B_{i,f,t-1}, B_{i,f,1} = 1 \tag{2}$$

[3] This does not mean that foreign inflows are fixed. Growth in such inflows is constant when inflows are treated exogenously. Moreover, to support the existence of a steady state equilibrium, growth rate of foreign has to be the same as the long-run economic growth rate.

In Equation (2), g_f is an exogenous part of the factor productivity growth rate that is not linked with increased public investment, and $g_{i,t}^{p}$ is an endogenous part of the productivity growth rate that is the outcome of increased public investment. Both g_f and $g_{i,t}^{p}$ are positive for inputs of labor and land and zero for capital in each sector. $g_{i,t}^{p}$ is determined by the growth in public investment financed through increased oil revenue only, that is:

$$g_{i,t}^{p} = \varepsilon_i \left(\frac{\Delta K_t^{p}}{K_t^{p}} - \frac{\Delta K_t^{p,0}}{K_t^{p,0}}\right) \tag{3}$$

where K_t^{p} and $K_t^{p,0}$ are, respectively, the public capital stock formed by the public investment in the situation with oil revenue and without, ΔK_t^{p} and $\Delta K_t^{p,0}$ are the public investment at time t with and without oil revenue, and ε is the elasticity of productivity growth with respect to additional growth in the stock of public capital, and $0 < \varepsilon_i < 1$.

Recognizing the separability of the consumer's intratemporal decision problem from his or her intertemporal choices, the consumer's optimization can be divided into two components. In the first component the representative consumer in the economy maximizes the overall utility defined in Equation (4) by choosing a composite consumption good intertemporally, and in the second component he or she chooses each sector's good intratemporally for a given amount of the composite good defined in Equation (5) and the current budget constraint defined in Equation (6):

$$\text{Max } U_1 = \sum_{t=1}^{T} (1+\mu)^{-t} \frac{Q_t^{1-\sigma}-1}{1-\sigma} + \frac{(1+\mu)^{1-T}}{\mu} \frac{Q_T^{1-\sigma}-1}{1-\sigma} \tag{4}$$

$$Q_t = \prod_i \left(c_{i,t} - \gamma_i\right)^{\vartheta_i} \tag{5}$$

$$\text{s.t. } PQ_t \cdot Q_t = Y_t - S_t^{h} \text{ and } PQ_t \cdot Q_t = \sum_i P_{i,t} \cdot c_{i,t} \tag{6}$$

In Equation (4), U1 is the value of the intertemporal utility evaluated at time period 1's price of aggregate consumption (the composite good Qt), μ is the time discount rate for the representative consumer, and σ is the substitution elasticity over time. In equation (5), ci,t is the intratemporal consumption for sector good i, γ_i is the minimum consumption of this good and is constant over time, and ϑ_i is the intratemporal marginal budget share for consuming good i. In equation (6), PQt and Pi,t are, respectively, prices for Qt and ci,t at time t. Yt is the consumer's income in each time period, and S_t^{h} is his or her savings at time t, which, as in a typical Ramsey one-sector framework, is an endogenous variable. In the general equilibrium framework, we assume that factor incomes, which are endogenous variables, all go to households, together with the exogenous incomes transferred from the government and abroad through remittances. Specifically:

$$Y_t = \frac{\sum_f W_{f,t} V_{f,t} + trns_{gov,t} + trns_{row,t}}{PoP_t}, \text{ and } V_{f,t} = \sum_i v_{i,f,t} \tag{7}$$

where wf is returns to factor f, Vf is the total supply of factor f, trnsgov and trnsrow are transfers received by all the households from the government and abroad, and PoP is the country's population. Besides capital that is endogenously accumulated over time, growth in labor and land supply is assumed to be exogenous. Similar as any intertemporal general equilibrium model, a complete labor market is assumed such that wage rate is an endogenous variable. Along the transitional equilibrium path, wage rate is not only affected by the change in labor allocation across sectors over time, but also affected by the productivity growth. To simplify the model, we assume that the labor growth rate is the same as the population growth rate,[4] while land expansion is assumed to be slower than population growth. This implies that productivity growth for land (used by agricultural production only) must be faster than productivity growth for labor such that the differential transitional growth across sectors can eventually reach the same steady-state growth in the long run.

We skip the detailed discussion about the Euler equation for the consumer problem and the no-arbitrage condition for the investment problem, the two most important intertemporal equations in the model. We also skip the discussion on the factor demand functions and commodity and factor market equilibrium conditions, which are similar to those in a static general equilibrium model (see Appendix for the mathematical presentation of the model). We focus on the government account in the rest of this section.

The government has five interrelated functions in the model before oil is found in Ghana: to collect taxes, to distribute transfer payments to consumers, to purchase goods and services through its recurrent expenditures, to allocate parts of its revenue to public investment (through savings), and to administer foreign debt. The model is set up so that both the government's savings and overseas borrowing grow exogenously at a fixed rate consistent with the combination of the exogenous part of the factor productivity growth rate and population growth. The annual recurrent expenditure is thus a residual term determined by the difference between government revenue and savings (including the payment to serve foreign debt). After oil is found, managing oil revenues becomes an additional government function. We assume that part of the oil revenue is owned by the government while the rest is owned by foreign companies and will not be spent in Ghana's domestic market. This assumption is based on the fact that oil extraction will be conducted offshore and that foreign companies usually repatriate profits, and on the enclave nature of the oil sector. Oil revenues that accrue to the government take the form of royalties and taxes paid by the consortium of oil companies[5] to the government. Accordingly, we model the oil boom as an increase in GDP (a statistical effect) and in foreign exchange revenues to the government.

Corresponding to the first five functions of the government, there are many different options for oil revenue management. We focus on three options that are most relevant to the current study. They are (1) to spend all petrodollars in each year as recurrent expenditure; (2) to invest 50 percent of oil revenue in productivity-enhancing public goods and services and allocate the remaining 50 percent to recurrent spending; and (3) to save 50 percent of oil revenue into an oil fund that invests in riskless foreign assets and earns a fixed income from these foreign assets in the future, and then to spend a certain percentage of the accumulated oil fund in the future. Together with 50 percent of current oil revenue, the spending will be equally split between public investment and recurrent expenditures. The first option can be seen as an example of a painful lesson that many oil-rich developing countries in the past experienced when oil was first found in their territory (see, for example, Harberger [2009] in the cases of Venezuela and Mexico). The second option is designed to evaluate whether a "smart" way of using oil revenues can overcome the negative Dutch disease effect. The third option reflects the practice of some oil-rich countries that have long experience in managing their natural resource revenues sustainably by using an allocation formula. The best self-restrained oil management model is Norway's, which is based on a principle that oil is "national capital under the ground," and it should remain national capital after it is extracted. With this option, the oil fund, which is invested in riskless or low-risk foreign assets, becomes permanent income-producing capital. The above three options can be formally presented as follows:

[4] Unemployment has to be ignored in the neoclassic setting of an intertemporal general equilibrium model in which the wage rate is an endogenous variable and is determined by intra-temporal the labor market equilibrium conditions. While for a country like Ghana the perfect labor market assumption is rather strong, relaxing this assumption will not modify the major model results. Actually, existence of unemployment in the early stage of development seems to further support the paper's major finding, i.e., the structure of the economy is not favorable for the development of labor intensive nonagricultural sectors.

[5] The consortium of oil companies comprises Tullow Oil, Kosmos Energy, and several other small-scale foreign operators. The Ghanaian government's share of oil revenues is expected to be around 40 percent of total oil revenues.

$$TY_t^{oil} = a \cdot CY_t^{oil} + (b + r) \cdot LY_{t-1}^{oil} \quad (8)$$

In Equation (7), TY_t^{oil} is total government income created from the oil sector; CY_t^{oil} and LY_t^{oil} represent, respectively, the current oil extraction revenue and the oil fund; and $(b + r)LY_t^{oil}$ is the income earned or drawn from the oil fund. a represents the oil revenue allocation rule, b is the oil fund drawing rule, and r is the rate of return from investing in riskless foreign assets. In the first two options, a is 1.0 and LY is zero. Thus, b becomes irrelevant. In the third case, a is chosen to be 0.5, and r is around 0.12. We choose b to be at the same value as the long-run growth rate, that is, 0.051.

The accumulation of the oil fund is as follows:

$$LY_t^{oil} = (1 - a) \cdot CY_t^{oil} + (1 - b) \cdot LY_{t-1}^{oil}, \text{ and } LY_1^{oil} = (1 - a) \cdot CY_1^{oil} . \quad (9)$$

We calibrate the model to a new 2007 social accounting matrix (SAM) for Ghana, which is based on a 2005 SAM documented in Breisinger, Duncan, and Thurlow (2007). To update this SAM to 2007, we use national accounts provided by Ghana Statistical Services (GSS) for 2007, balance-of-payments data provided by the Bank of Ghana, and government budget data provided by the Ministry of Finance. While the newly developed SAM provides information on the demand and production structures of much more detailed sectors, for the purposes of this study we aggregate the economy into five sectors: (1) export agriculture, (2) other agriculture, (3) mining, (4) tradable nonagriculture, and (5) nontradable nonagriculture. Although we include nontraditional agriculture exports in the export agricultural sector, the sector is primarily dominated by cocoa and forestry, the most important traditional agricultural export products in Ghana. “Other agriculture” can be understood as a staple sector that includes both staple crops and livestock to mainly meet domestic food demand. Mining is an export sector and is dominated by gold in Ghana. We distinguish tradables from nontradables in the economic activities other than agriculture and mining because of the expected differential impact of the oil boom on these sectors. The tradable sector is dominated by manufacturing (which is highly import-dependent) and exportable services, while the nontradable sector includes construction, utilities, and private and public services.

We calibrate the model without considering the oil boom and then shock the model by introducing oil revenues in three different simulations. To assess whether the model projections fit with the actual performance of the economy in the past, we first conduct a backcasting exercise with the model. We find that the growth path for GDP and agricultural GDP matches the actual performance of the economy well between 1995 and 2007 (see Figure A2 in Appendix). After that, we run the model starting in 2007 and extending to 2050 for the three scenarios corresponding to the three oil allocation options discussed above.

3. THE DUTCH DISEASE OF THE OIL BOOM: SHORT- AND MEDIUM-RUN IMPACTS ON GROWTH AND ECONOMIC STRUCTURE

In all three oil management scenarios, oil revenue grows at the same rate. Oil revenue growth is assumed to be rapid in the first five years after oil is found—a common observation in most countries where oil is discovered and extracted. After the first five years, oil revenues are assumed to grow steadily at a constant rate. Under the three scenarios, we further consider two situations in terms of medium- to long-run oil revenue growth. In the first situation, the medium- and long-run oil revenue growth rates are the same and are consistent with long-run GDP growth; thus, the ratio of oil revenue to GDP is relatively stable at 10 percent in the long run. In the second situation, the medium-run oil revenue growth rate is higher than the long-run trend, and oil revenue rises to about 13 percent of GDP by 2030. After 2030 oil growth slows to the long-run GDP growth rate, and thus the ratio of oil revenue to GDP becomes constant (around 13 percent) in the long run. These two different oil growth rates can also serve as a sensitive test for how the difference in oil revenue growth affects the model results. In this section, we focus on the first oil scenario, in which all oil revenue is spent by the government on recurrent items. We first discuss the short-run impact of this oil management option.

In the short run, the expected outcome of a sudden increase in foreign inflows is an increase in the government's demand for both domestic and imported goods. This causes prices for nontradable goods to rise and imports to increase. Increases in the prices of nontradable goods result in real exchange rate appreciation, which tends to pull resources away from the tradable sector and further lowers exports and induces additional imports. This type of Dutch disease effect is defined as the short-run impact when the growth rate impact has not been taken into consideration. Consistent with this broadly accepted Dutch disease outcome, the model shows that while oil increases total GDP statistically, growth in the tradable sectors, including the export agricultural and tradable nonagricultural sectors, actually declines sharply, particularly in the first year when oil revenues flow, while growth in nontraded nonagriculture rises significantly, from 5.6 percent in the base run's 2010 to 8.4 percent. This structural effect of oil inflows leads to a decline in non-oil GDP growth (Table 1).

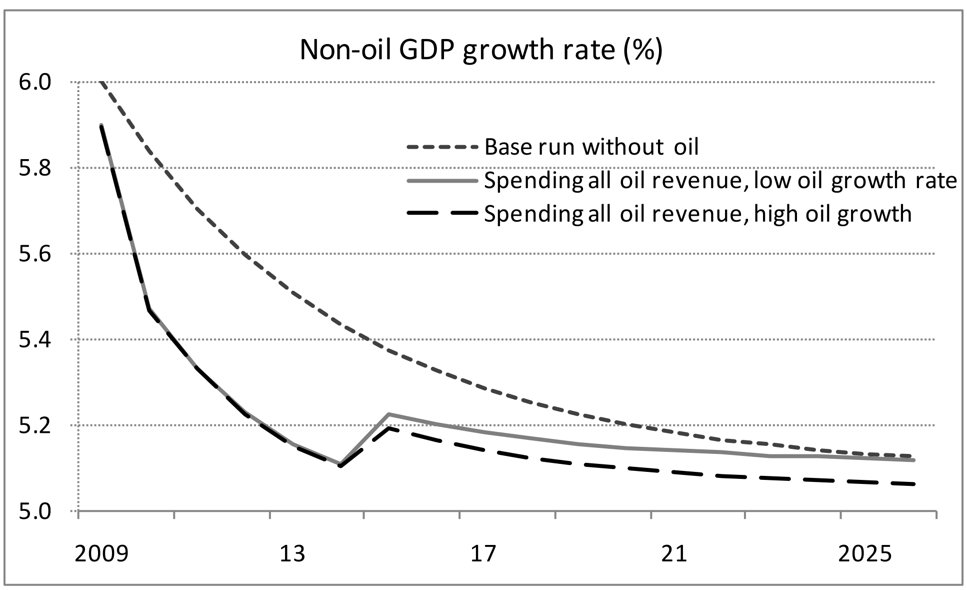
Table 1. Short-run impact of oil revenue: Annual growth rate of total and sectoral GDP in the first five years under the model's base run and first oil scenarios

		2010	2011	2012	2013	2014	2015
Total GDP with oil	Oil-1	13.8	12.3	11.1	10.1	9.4	5.2
Total non-oil GDP	Base run	5.8	5.7	5.6	5.5	5.4	5.4
	Oil-1	5.5	5.3	5.2	5.2	5.1	5.2
Domestic agriculture	Base run	4.8	4.8	4.8	4.8	4.8	4.8
	Oil-1	4.6	4.7	4.7	4.7	4.7	4.8
Export agriculture	Base run	4.4	4.6	4.9	5.1	5.3	5.5
	Oil-1	-0.3	0.6	1.4	2.0	2.5	6.0
Tradable nonagriculture	Base run	5.1	5.1	5.1	5.1	5.1	5.1
	Oil-1	2.2	2.4	2.6	2.9	3.1	5.3
Nontraded nonagriculture	Base run	5.6	5.5	5.4	5.3	5.3	5.3
	Oil-1	8.4	7.9	7.5	7.1	6.8	5.2

Source: The simulation result of the multisector intertemporal general equilibrium model for Ghana.
Notes: 1. Total oil revenue is assumed to equal the total value added of the new oil sector (given that extraction of oil is highly capital intensive and uses few intermediate inputs). Statistically, the oil sector's total value added (including the part shared by the foreign company) is counted as part of Ghana's GDP, which explains the sudden increases in the total GDP growth rate in the first few years when oil starts to be extracted—a similar situation observed in the other countries.
2. Oil-1 indicates the first oil scenario, in which all oil revenue is spent on recurrent government expenditures.

While the short-run impact presented in Table 1 is consistent with the general prediction of the Dutch disease theory, the theory itself does not provide a prediction of the longer term impacts. In this paper we focus on the longer term impact of oil revenue inflows on transitional growth, which can be analyzed using the intertemporal general equilibrium model. The longer term impact of oil revenue inflows is a combination of the allocation effect from the change in relative prices over time and the accumulation effect due to slower growth in savings and investment. This impact can be analyzed as the effect on the overall economy (growth effect on the non-oil economy) and on the different sectors (structural effect). The structural effect is due to differential growth across sectors as an outcome of the allocation effect. That is, the midterm growth rate increases in the nontraded sectors and declines in the tradable sectors. The growth effect is primarily an outcome of the accumulation effect, that is, responding to the change in economic structure, the overall growth in the non-oil economy slows with the decline in investment growth. However, constrained by the steady-state equilibrium condition in which productivity growth is exogenous and constant, in the long run sector growth converges and the long-run GDP growth rate in the scenarios with oil revenue equals that in the base run without oil revenue. The model also shows that the magnitude of the medium-run effect depends on the level of oil revenue growth. The higher the medium-run oil revenue growth rate is above the long-run GDP growth rate, the stronger the negative overall growth effect on the non-oil economy and the larger the structural effect in the medium run. We use Figure 1 to show the overall growth effect on the non-oil economy and Table 2 to show the structural effect in the medium run as the outcome of oil revenue inflows. In both the figure and the table, the growth rate of oil revenues in the "low oil growth" scenario is 5.06 percent annually after the first five years' oil boom until 2030. This growth is consistent with the long-run GDP growth in the base run, while in the "high oil growth" scenario, oil revenue grows at 7.62 percent annually over the same period.

Figure 1. Medium-run overall growth effect of oil revenue inflows



Source: The simulation result of the multisector intertemporal general equilibrium model for Ghana.
Note: The low oil growth rate is 5.06 percent and the high oil growth rate is 7.62 percent.

Given that all oil revenue is spent on recurrent government expenditures in the first oil scenario discussed in this section, the medium-run negative growth effect is only the result of slower capital accumulation and changes in factor allocation, while the productivity growth rate at the sector level is still the same as in the base run. Thus, as displayed in Figure 1, the negative medium-run growth effect of oil revenue inflows on the aggregate economy (measured by non-oil GDP) diminishes over time, and long-term investment and hence capital accumulation will be consistent with long-run productivity and population growth in all the scenarios. While the negative growth effect diminishes in the long run, the structure of the economy is affected permanently. This can be seen clearly from Table 2, in which the non-oil GDP share of the nontraded nonagricultural sector rises from 41.1 percent in the base run's 2030 to 46.2–48.5 percent in the first oil scenario in the same year. The higher share of the nontraded sector's GDP (48.5 percent) corresponds to the higher medium-run growth rate of oil revenue inflows. Moreover, this structural change becomes permanent if oil revenue continues to flow to the country in the long run. The long-term structural effect of oil revenues poses a huge challenge to countries such as Ghana and may undermine their industrialization process. The manufacturing sector remains small in many African countries, accounting for 10–15 percent of the economies. Instead of a growing manufacturing sector, the continuous expansion of nontraded industrial (construction) and service sectors, together with rapid urban population growth, seems to lead to urbanization without industrialization. This resource-driven development reflects the difficulty many African countries experience in pursuing sustained and broad-based growth that allows the majority of the population to participate in the growth process.

Table 2. Non-oil sector's GDP share (total non-oil GDP = 100)

	Base run	**Spending all oil revenue**	
		Low oil growth	**High oil growth**
2010			
Staple agriculture	22.7	22.8	22.8
Export agriculture	11.0	10.6	10.6
Tradable nonagriculture	16.2	15.8	15.8
Nontraded nonagriculture	41.6	42.8	42.8
2030			
Staple agriculture	20.9	21.4	21.5
Export agriculture	12.0	10.5	9.6
Tradable nonagriculture	15.9	14.6	13.8
Nontraded nonagriculture	41.1	46.2	48.5

Source: The simulation result of the multisector intertemporal general equilibrium model for Ghana.
Note: The low oil growth rate is 5.06 percent and the high oil growth rate is 7.62 percent.

Can oil revenue be used smartly so that the negative growth and structural effect can be mitigated by better oil revenue management? We design two additional oil scenarios to investigate this possibility. In the next section, we first focus on the role of government investment financed by oil revenues before turning to the role of an oil fund in the remainder of the section.

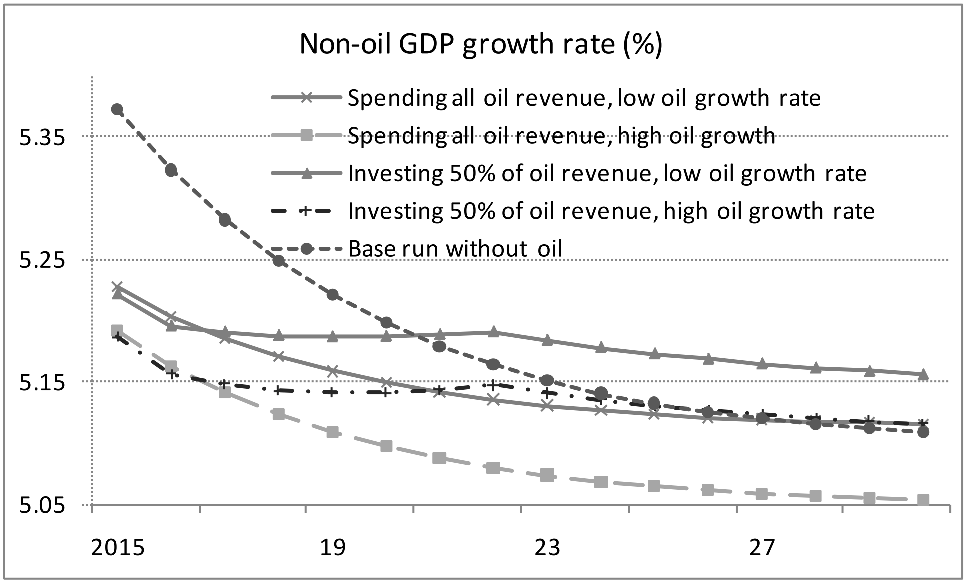
4. CAN SMART USE OF OIL REVENUE MITIGATE DUTCH DISEASE?

The analysis in the previous section shows that the Dutch disease effect of oil revenue inflows on growth and the structure of the economy can become permanent if these inflows last long and are spent on recurrent government expenditures. A smart use of oil revenues, thus, should reconsider this type of spending pattern. We consider two alternative oil revenue allocation options, as introduced in Section 2: (2) investment instead of recurrent spending and (3) the creation of an oil fund. In case (2), additional investment financed by oil revenues does not reduce additional demand by the government in the domestic market, and thus, if there is no externality effect of public investment on growth, the result of this scenario is expected to be similar to that of the first oil scenario. In case (3), the creation of an oil fund reduces the amount of oil revenue available for recurrent spending, and hence the oil fund is expected to partially mitigate the Dutch disease effect. The more oil revenue is allocated to the oil fund, the less oil income is available to the government and the weaker the Dutch disease effect. However, with increased oil revenue and the accumulation of the oil fund over time, revenue from continuous oil inflows and from oil fund withdrawals will eventually increase and be spent by the government. This implies that an oil fund can postpone the Dutch disease effect but may be unable to fully mitigate it over time. Thus, to overcome the negative effect of oil revenue inflows, productivity-enhancing public investments can be an option to accelerate growth. We investigate the outcome of this option using the model.

Linkages between public investment and productivity growth are an empirical issue, and no structural model exists to formally analyze such linkages. As an empirical issue, the magnitude of the productivity enhancement of public investment varies in the literature due to differences in estimation methods, country and sector focus, and datasets used for estimation. Moreover, a country’s institutional and policy environment matter in determining the efficiency and effectiveness of public investments. The purpose of the scenarios designed in this paper is not to assess whether public investment can stimulate productivity growth in the private sector and what the magnitude of such an impact may be. Rather, we focus on whether investment can fully mitigate the Dutch disease effect on both growth and structural change. In the simulations, we assume that the spillover effect of public investment on productivity occurs in the 10th year, and that the effect is modest from the 10th to the 15th year and then takes full effect after that. Specifically, we define the elasticity ε in equation (3) of Section 2 to be 0.01–0.05 between the 10th and 14th year and 0.06 for all the years after the 14th year. These elasticities imply that for each 1 percent additional growth in public investment, the productivity growth rate of labor and land increases by 0.01–0.05 percentage points in the 10th to the 14th year and by 0.06 percentage points after that. Consistent with the previous section, we further consider two different oil revenue growth rates in the medium run. For example, with the higher oil growth rate and without the creation of an oil fund, investing 50 percent of oil revenue is associated with an annual productivity growth rate of 2.66 percent by the 16th year, rising from 2.5 percent in the base run. The productivity growth rate starts to fall when the oil revenue growth rate converges to its long-run rate after the 25th year. In the long run the productivity growth rate is only slightly higher (2.54 percent) than in the base run (2.50 percent).

We first focus the discussion on the growth effect of oil-financed public investment. In Figure 2, we present the non-oil GDP growth rates between 2015 and 2030 to show the medium-run effect of oil-financed public investment. The GDP growth path differs depending on the oil growth rate. Under the low oil growth rate situation, annual non-oil GDP growth bounces back to its base-run level in the 15th year (2021) and stays above the base-run growth rate in subsequent years. Under the high oil growth situation, non-oil GDP growth returns to its base-run level six years later, in the 21st year (2027), and is only slightly higher than the base-run growth rate after that. It should be noted that more oil revenue is invested under the high oil growth situation compared to the low oil growth situation. While more net gain in additional GDP growth as the result of additional productivity growth is seen in the case with the high oil growth rate than in that with the low oil growth rate (which is captured by a relatively wider gap between the two growth paths corresponding to the two oil scenarios with the high oil growth rate than between the scenarios with the low oil growth rate in Figure 2), productivity growth as the result of increased public investment cannot compensate the loss in non-oil GDP growth due to the high oil growth rate in the medium run. The results of the second oil scenario indicate that the positive productivity effect of oil-financed public investment is not always able to mitigate the negative growth effect of the Dutch disease in the medium run. The conclusion depends on the efficiency and effectiveness of public investment in stimulating productivity growth. Yet, with the same investment-to-productivity-growth elasticity, it can be said that the more oil revenue flowing in the country each year, the less likely the public investment to fully mitigate the negative growth effect of Dutch disease.

Figure 2. Growth effect of oil revenue inflows – investing vs. spending



Source: The simulation result of the multisector intertemporal general equilibrium model for Ghana.
Note: The low oil growth rate is 5.06 percent and the high oil growth rate is 7.62 percent.

Now we turn to the structural effect of oil-funded public investment. As discussed in the previous section, the tradable sector's growth is negatively affected by the oil inflows. Thus, we assume that oil-funded public investment particularly targets productivity growth in the two agricultural sectors and the tradable nonagricultural sector, while productivity in the nontraded nonagricultural sector and the mining sector will not benefit directly. For the structural effect, we focus the discussion on both the medium and long run and, in Table 3, report GDP shares for the four main economic sectors in 2030 and 2050 under different scenarios with the two different oil growth rates. Some of the results shown in Table 3 were already reported in Table 2, but, for the purpose of comparison, we include them again. Comparing the result under the second oil scenario ("investing 50% of oil revenue") with that under the first oil scenario ("spending all oil revenue"), GDP shares for the export agriculture and tradable nonagricultural sectors slightly increase when public investment raises productivity growth in these two sectors. However, the role of public investment in mitigating the economic structural effect is very modest both in the medium run and in the long run. The nontraded nonagricultural sector continues to expand from its base-run level, even though the sector is assumed not to benefit directly from increased public investment. Again, with the same investment-to-productivity-growth elasticity, a high oil growth rate (even though higher oil growth also indicates more oil-funded investment) makes public investment less effective in mitigating the structural effect of oil inflows.

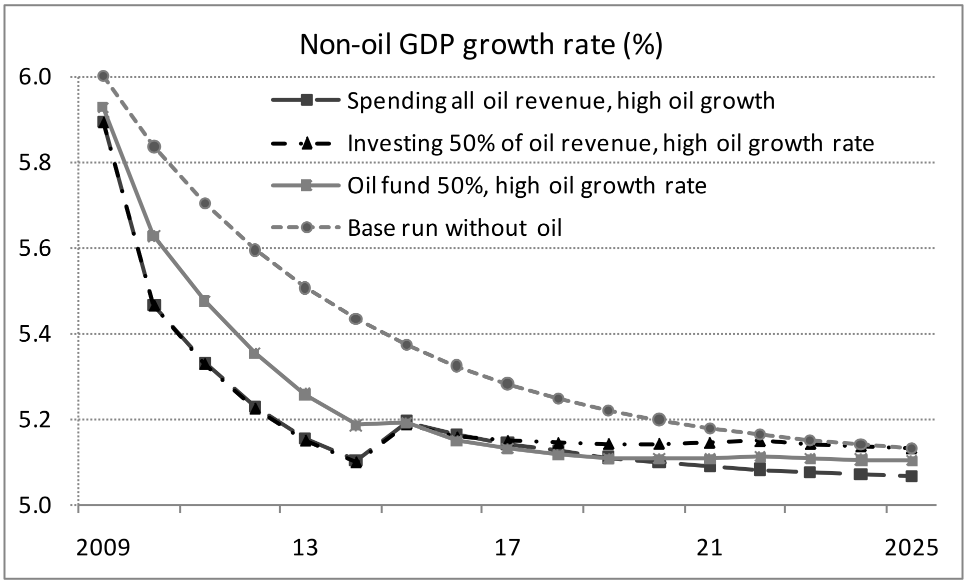
Table 3. Structural effect of oil revenue inflows under different oil management scenarios (total non-oil GDP = 100)

		Low oil growth rate			High oil growth rate		
	Base run	Spending all oil revenue	Investing 50% of oil revenue	Oil fund 50% of oil revenue	Spending all oil revenue	Investing 50% of oil revenue	Oil fund 50% of oil revenue
2030							
Staple agriculture	20.9	21.4	21.5	21.5	21.5	21.7	21.6
Export agriculture	12.0	10.5	10.9	11.0	9.6	10.0	10.4
Tradable nonagriculture	15.9	14.6	14.7	14.8	13.8	13.9	14.2
Nontraded nonagriculture	41.1	46.2	46.0	45.7	48.5	48.2	47.3
2050							
Staple agriculture	20.0	20.5	20.6	20.7	20.6	20.9	20.9
Export agriculture	14.2	12.2	12.8	12.9	11.1	11.9	11.9
Tradable nonagriculture	15.8	14.4	14.5	14.5	13.6	13.7	13.7
Nontraded nonagriculture	41.5	46.4	46.0	46.0	48.7	48.1	48.1

Source: The simulation result of the multisector intertemporal general equilibrium model for Ghana.
Note: The low oil growth rate is 5.06 percent and the high oil growth rate is 7.62 percent.

In the third oil scenario, 50 percent of current oil revenues are allocated into an oil fund, and the rest are split equally into investment and recurrent spending. The risk-free return (which equals the interest rate) from the oil fund, together with 5.1 percent of oil fund stock, is spent in the same way as the 50 percent of the current oil inflows. As the speed of spending oil revenue slows in the short and medium runs in this scenario compared with that in the two previous scenarios, the short-run shock on GDP growth becomes relatively modest but still exists (Figure 3). However, because less oil revenue is allocated to investment each year, given a similar oil growth rate, the growth enhancement effect in the medium run is also more modest with the oil fund than without it. But given that the speed of spending oil fund revenues is assumed to be similar to the growth rate of oil revenues in the long run, the available oil revenue to be spent each year is similar in all three oil scenarios in the long run. Thus, the long-run structural change effect is indifferent under the three alternative oil management options, while there is a slight improvement in the structural effect in the medium run when an oil fund is created (see the results of the third columns under both low and high oil growth rates in Table 3).

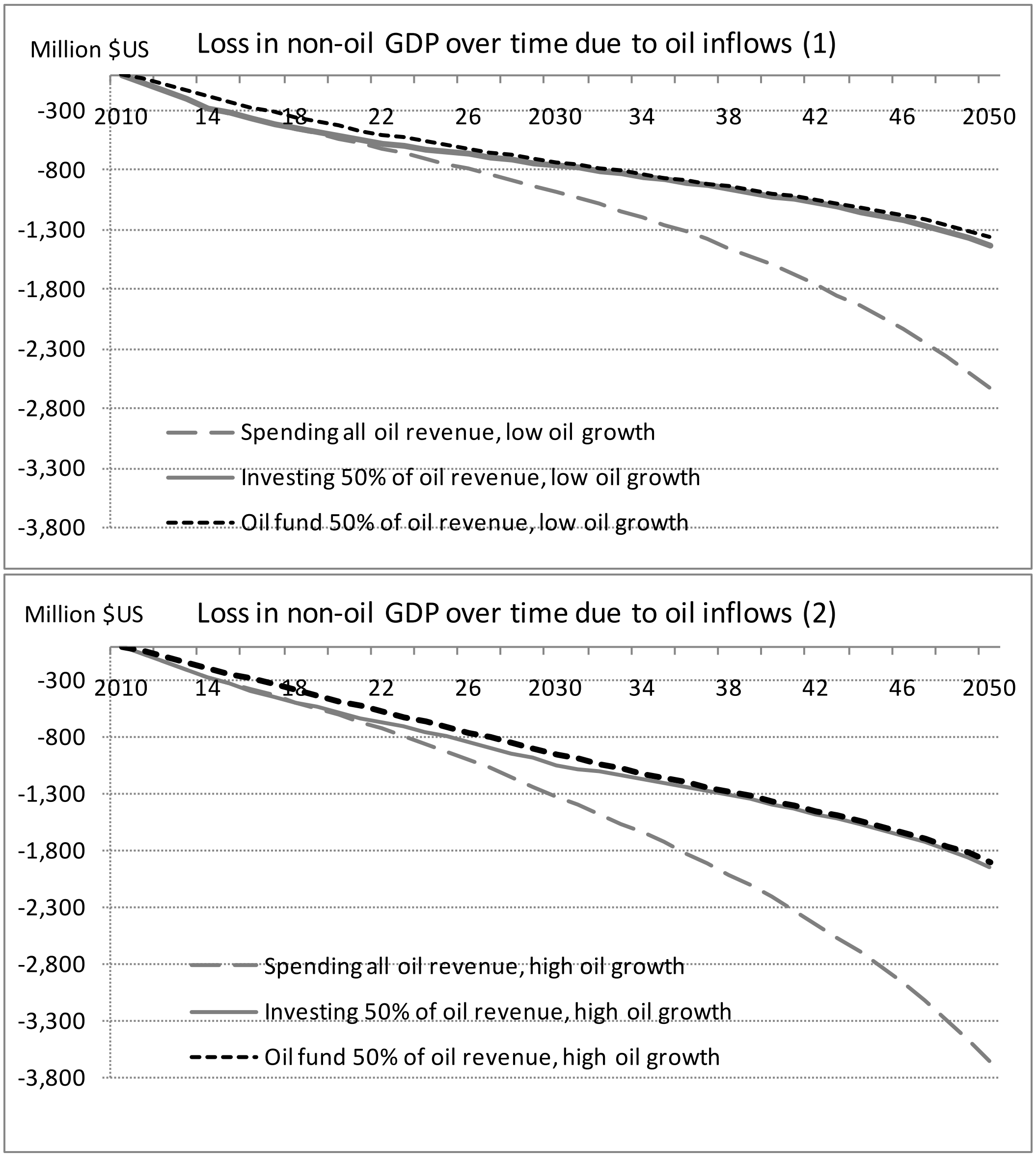
Figure 3. Short- to medium-run effect of alternative oil management options on GDP growth



Source: The simulation result of the multisector intertemporal general equilibrium model for Ghana.
Note: The high oil growth rate is 7.62 percent.

Finally, we show in Figure 4 the negative effect of oil inflows on the level of non-oil GDP over the entire simulation period (2010–2050) under the three oil management scenarios. Again, we also consider two different oil growth rates in each of the three scenarios. We report this effect as the difference from the base run's GDP level in the same year. The first panel of Figure 4 reflects the three scenarios with low oil growth while the second panel of the figure represents the same scenarios with high oil growth. The loss in GDP is significant if there is no measure to mitigate the Dutch disease: GDP will be US$2.62–3.66 billion less compared to the base run by 2050, where the lower number is for the low oil growth rate and the higher number is for the high oil growth rate. The mitigating effect of the two alternative oil management options is similar in the long run: The loss in GDP is reduced to US$1.44–1.95 billion in the second oil scenario and to US$1.36–1.90 billion in the third oil scenario.

Figure 4. Impact of oil inflows on the level of non-oil GDP over time under the three oil management options



Source: The simulation result of the multisector intertemporal general equilibrium model for Ghana.
Note: The low oil growth rate is 5.06 percent and the high oil growth rate is 7.62 percent.

5. CONCLUSIONS

Foreign inflows are important sources of income that many African governments use to finance investments. Many countries intend to follow the Asian model and gear foreign inflows toward enhancing export-oriented manufacturing or service sectors to accelerate economic growth and structural transformation. Yet in many African economies the manufacturing sector has grown more slowly than other sectors, and rapid growth in domestic-oriented industries (urban construction and utilities) and services has made these sectors the largest in their economies. Motivated by these stylized facts, we use Ghana and its newly found oil as an example and analyze the dynamic relationship between increased inflows of petrodollars, economic growth, and structural change. The analysis is based on an intertemporal general equilibrium model with five economic sectors and three alternative oil revenue management options.

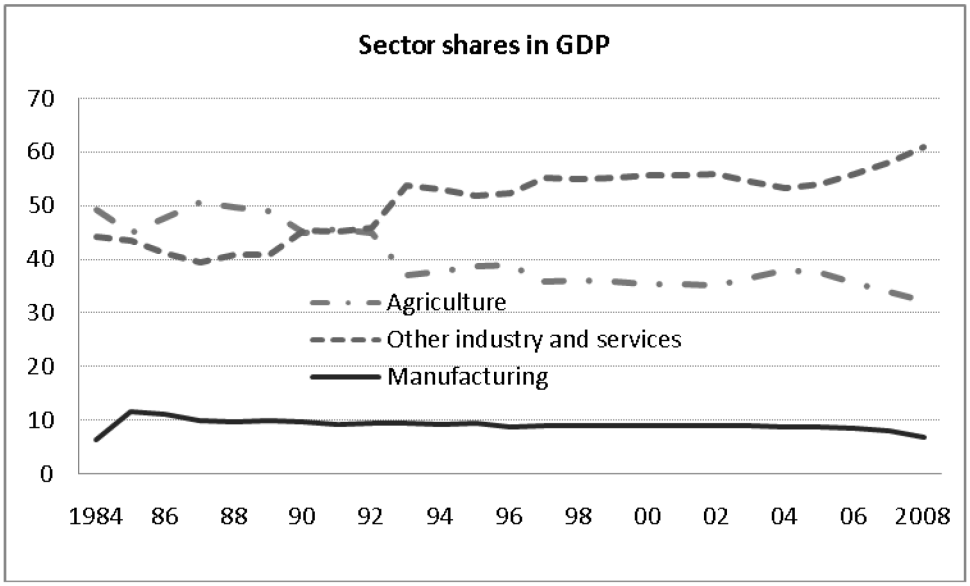
We find that the increased foreign inflows from petrodollars generate a substantial short-run growth shock in non-oil sectors, as predicted by the Dutch disease theory, if the oil revenues are used by the government to finance either recurrent spending or public investment. The growth reduction in the tradable sectors and increase in the nontraded sectors cause the structure of the economy to become more nontradable dominated. When the creation of an oil fund reduces the availability of oil revenues to be spent by the government in the short run, the negative growth effect becomes relatively modest. In the medium run, if oil spending does not enhance productivity growth, the rate of non-oil economic growth slows and the GDP share of the nontraded sector in the economy further increases. Moreover, the impact on the economic structure persists as long as oil revenue continues to flow in the country. Thus, Dutch disease can be a longer term phenomenon and a challenge for growth.

Smart use of oil revenues requires not only the creation of an oil fund but also the financing of productivity-enhancing public investment. While the mitigating role of public investment depends on its effectiveness and efficiency, our paper emphasizes that the growth magnitude of oil inflows matters for the mitigation effect. At the same level of investment-to-productivity-growth efficiency, and if the inflows continue to grow at a relatively high rate, it takes the economy longer to overcome Dutch disease than in a situation in which the inflows grow at a slower pace. Moreover, our paper shows that the structural effects of Dutch disease on economic development are more difficult to correct and in fact can become a persistent phenomenon in countries that continue to receive foreign inflows in the form of petrodollars or in any other forms.

Obviously, the longer term structural effect of foreign inflows poses a huge challenge to economic transformation in African countries such as Ghana. The rigidness in their economic structures challenges these countries as they attempt to pursue sustained and broad-based growth in which a majority of the population participates and poverty is reduced. Although the importance of institutional and historical factors for understanding the challenges faced by African countries in achieving sustainable and broad-based growth has been broadly discussed in the literature, challenges posed by significant increases in foreign inflows over the past two decades deserve more attention and assessment.

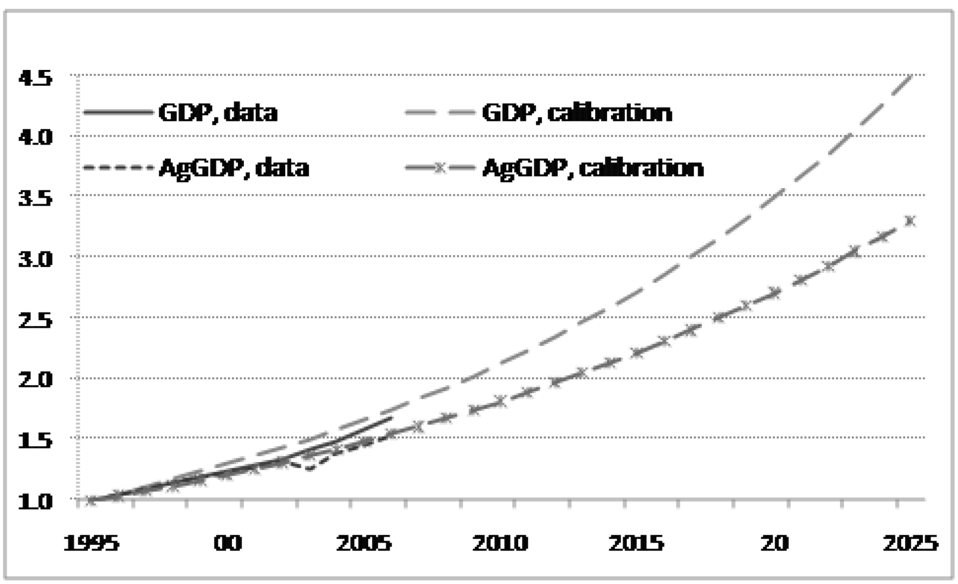
APPENDIX A: SUPPLEMENTARY FIGURES

Figure A.1. Sector shares in GDP (Ghana: 1984–2008)



Source: Authors' calculation based on World Bank 2010.
Note: "Other industry" includes construction, urban utilities, and mining.

Figure A.2. Model calibration of GDP and agricultural GDP ()



Source: Backcast base run of the multisector intertemporal general equilibrium model for Ghana.
Note: Normalized, value in 1995 = 1.

APPENDIX B: MATHEMATICAL PRESENTATION OF THE MULTISECTOR INTERTEMPORAL GENERAL EQUILIBRIUM MODEL

A.1. Glossary

A.1.1. Parameters

Λ_i : Shift parameter in Armington import function for good *i*

Γ_i : Shift parameter in Constant Elasticity of Transformation (CET) export function for good *i*

A_i : Shift parameter in value-added production function for good *i*

β_i : Share parameter in Armington import function for domestically produced good *i*

η_i : Share parameter in CET export function for domestically produced good *i*

$\alpha_{i,f}$: Share parameter in value-added production function for good *i* and factor *f*

$io_{i,j}$: Input-output coefficient for good *i* used in sector *j*

θ_i : Marginal budget share for good *i* consumed by consumers

γ_i : Subsistence parameter for good *i* in composite good

ϖ_i : Share parameter for good *i* consumed by government

π_i : Share parameter for good *i* used for investment

a : Allocation rule for current oil revenue

b : Allocation rule for oil fund

ε_i^M : Elasticity of substitution in Armington import function for good *i*

ε_i^E : Elasticity of substitution in CET export function for good *i*

φ_i : Elasticity of substitution in value-added production function for good *i* and $\varphi_i = \frac{1}{1+\rho_i}$

σ : Elasticity of substitution in intertemporal utility function

μ : Time preference in intertemporal utility function

λ : Parameter in capital adjustment function

δ : Capital depreciation rate

g_f : Exogenous growth rate of factor *f*'s productivity

ε_i : Elasticity of increased productivity growth rate with respect to increased public capital stock from its base-run level

A.1.2. Exogenous variables

$V_{f,t}$: Level of labor and land supply

$V_{k,1}$: Initial level of capital supply as $f = k$

PoP_t: Level of population

$trns_t^{gov}$: Transfer from government to households

$trns_t^{row}$: Transfer from rest of world to households

S_t^{gov}: Government savings

S_t^{row}: Exogenous foreign inflows irrelevant to oil revenues

CY_t^{oil}: Exogenous oil revenue inflows

LY_t^{oil}: Stock of oil fund

TY_t^{oil}: Total oil-related revenue spent at time t

$PWE_{i,t}$: World FOB price for good i

$PWM_{i,t}$: World CIF price for good i

$\tau_{i,t}^{M}$: Tariff rate

$\tau_{i,t}^{E}$: Export tax

$\tau_{i,t}^{X}$: Value-added tax

$\tau_{i,t}^{CC}$: Sales tax

EXR_t: Exchange rate

$DEBT_1$: Initial level of foreign debt

K_t^P: Stock of public investment with oil revenue spent on public investment

$K_t^{P,0}$: Stock of public investment without oil revenue spent on public investment

ΔK_t^P: Flow of public investment with oil revenue spent on public investment

$\Delta K_t^{P,0}$: Flow of public investment without oil revenue spent on public investment

$B_{i,f,t}$: Level of factor productivity in value-added production function for good i and factor f

A.1.3. Endogenous variables

$PX_{i,t}$: Producer price for good *i*

$PVA_{i,t}$: Value-added part producer price for good *i*

$P_{i,t}$: Price for Armington good *i*

$PD_{i,t}$: Price for good *i* produced and consumed domestically

PQ_t: Price for composite good

$W_{f,t}$: Returns or wage rate for factor *f*

P_t^K: Unit value of investment

r_t: Interest rate in domestic capital market

$X_{i,t}$: Output of good *i*

$CC_{i,t}$: Armington good *i*

$E_{i,t}$: Exports of good *i*

$M_{i,t}$: Imports of good *i*

$Z_{i,t}$: Armington good *i*

$D_{i,t}$: Good *i* produced and consumed domestically

$C_{i,t}$: Consumer demand for good *i*

$C_{i,t}^{gov}$: Government demand for good *i*

$C_{i,t}^{J}$: Intermediate demand for good *i* by sector *j*

$C_{i,t}^{INV}$: Investment demand for good *i*

Q_t: Composite good

Y_t: Total household income

Y_t^{gov}: Government income

I_t: Capital investment in quantity

q_t: Tobin's q in capital adjustment function

S_t^H: Household savings

U_1: Intertemporal utility function

$g_{i,t}^P$: Endogenous part of factor productivity growth rate

A.2. Equations

A.2.1. Intratemporal equations

Armington import function and first-order condition for imports

$$P_{i,t} = \frac{1}{\Lambda_i}\left[\beta_i^{\varepsilon_i^M}\left(EXR_t \cdot (1+\tau_{i,t}^M)\cdot PWM_{i,t}\right)^{1-\varepsilon_i^M} + (1-\beta_i)^{\varepsilon_i^M} PD_{i,t}^{\;1-\varepsilon_i^M}\right]^{\frac{1}{1-\varepsilon_i^M}}$$

$$M_{i,t} = \Lambda_i^{1+\varepsilon_i^M}\left[\beta_i \frac{P_{i,t}}{EXR_t \cdot (1+\tau_{i,t}^M)\cdot PWM_{i,t}}\right]^{\varepsilon_i^M} \cdot CC_{i,t}$$

$$D_{i,t} = \Lambda_i^{1+\varepsilon_i^M}\left[(1-\beta_i)\frac{P_{i,t}}{PD_{i,t}}\right]^{\varepsilon_i^M} \cdot CC_{i,t}$$

CET export function and first-order condition for exports

$$PX_{i,t} = \frac{1}{\Gamma_i}\left[\eta_i^{-\varepsilon_i^E}\left(EXR_t \cdot (1-\tau_{i,t}^E)\cdot PWE_{i,t}\right)^{1+\varepsilon_i^E} + (1-\eta_i)^{-\varepsilon_i^E} PD_{i,t}^{\;1+\varepsilon_i^E}\right]^{\frac{1}{1+\varepsilon_i^E}}$$

$$E_{i,t} = \Gamma_i^{-(1+\varepsilon_i^E)}\left[\eta_i \frac{PX_{i,t}}{EXR_t \cdot (1-\tau_{i,t}^E)\cdot PWE_{i,t}}\right]^{-\varepsilon_i^E} \cdot X_{i,r}$$

$$D_{i,t} = \Gamma_i^{-(1+\varepsilon_i^E)}\left[(1-\eta_i)\frac{PX_{i,t}}{PD_{i,t}}\right]^{-\varepsilon_i^E} \cdot X_{i,r}$$

Value added, factor demand, and output prices

$$(1-\tau_{i,t}^X)\cdot PVA_{i,t} = \frac{1}{A_i}\left[\prod_{f\in F}\frac{\alpha_{i,f}^{\;\varphi_i}}{\widetilde{B}_{i,f,t}^{\;1-\varphi_i}}\cdot W_{f,t}^{\;1-\varphi_i}\right]^{\frac{1}{1-\varphi_i}}$$

$$PX_{i,t} = PVA_{i,t} + \sum_j io_{j,i} \cdot P_{j,t}$$

$$v_{i,f,t} = (A_i \widetilde{B}_{i,f,t})^{\varphi_i - 1}\left[\alpha_{i,f}\frac{(1-\tau_{i,t}^X)\cdot PVA_{i,t}}{W_{i,f,t}}\right]^{\varphi_i} \cdot X_{i,t}$$

Factor market equilibrium

$$V_{f,t} = \sum_i v_{i,f,t}$$

Government income, government demand, and intermediate and investment demand

$$C_{i,t}^{gov} = \varpi_{i,t} \cdot \frac{Y_t^{gov} - trns_t^{gov} - (r_t - g)\cdot DEBT_t - S_t^{gov}}{P_{i,t}}$$

$$C_{i,t}^{J} = io_{j,i,t} X_{j,t}$$

$$C_{i,t}^{INV} = \pi_{i,t} \cdot \frac{P_t^K I_t}{P_{i,t}}, \text{ for } i \neq \text{nontraded}$$

$$C_{i,t}^{INV} = \pi_{i,t} \cdot \frac{P_t^K I_t}{P_{i,t}} + \lambda \frac{I_t^2}{V_{k,t}}, \text{ for } i = \text{nontraded}$$

Household income and demand

$$C_{i,t} = \gamma_{i,t} + \frac{\theta_i \cdot (PQ_t Q_t - \sum_j P_{j,t}\theta_j)}{P_{i,t}}$$

$$PQ_t Q_t = Y_t - S_t^H$$

$$Y_t = \frac{\sum_f W_{f,t} V_{f,t} + trns_t^{gov} \quad + trns_t^{row}}{PoP_t}$$

Commodity market equilibrium

$$CC_{i,t} = C_{i,t} + C_{i,t}^{gov} + C_{i,t}^{J} + C_{i,t}^{INV}$$

Trade balance

$$\sum_i PWM_{i,t} M_{i,t} = S_t^{row} + trns_t^{row} + \sum_i PWE_{i,t} E_{i,t} + CY_t^{oil}$$

A.2.2. Intertemporal equations

Intertemporal utility function and Euler equation

$$U_1 = \sum_{t=1}^{T} (1+\mu)^{-t} \frac{Q_t^{1-\sigma} - 1}{1-\sigma} + \frac{(1+\mu)^{1-T}}{\mu} \frac{Q_T^{1-\sigma} - 1}{1-\sigma}$$

$$\frac{PQ_{t+1} Q_{t+1}}{PQ_t Q_t} = \frac{1 + r_{t+1}}{1+\mu}$$

Nonarbitrage condition with adjust cost for investment

$$(1+r_t) q_{t-1} = W_{k,t} + \lambda \cdot P_{i,t} \left(\frac{I_t}{V_{k,t}} \right)^2 + q_t \cdot (1-\delta), \text{ for } i = \text{nontraded}$$

Tobin's q

$$q_t = P_t^K + \frac{2 \cdot \lambda \cdot P_{i,t} I_t}{V_{k,t}}, \text{ for } i = \text{nontraded}$$

Capital accumulation

$$V_{k,t} = (1-\delta) \cdot V_{k,t-1} + I_t$$

Debt accumulation

$$DEBT_t = (1 + r_t) \cdot DEBT_{t-1}$$

Oil revenue, oil fund, oil spending, and public investment

$LY_t^{oil} = (1-a)\cdot CY_t^{oil} + (1-b)\cdot LY_{t-1}^{oil}$, and $LY_1^{oil} = (1-a)\cdot CY_1^{oil}$

$$TY_t^{oil} = a\cdot CY_t^{oil} + (b+r)\cdot LY_{t-1}^{oil}$$

$$\Delta K_t^{P,0} = \frac{S_t^{gov}}{P_{i,t}}, i = \text{nontraded}$$

$$\Delta K_t^{P} = \frac{S_t^{gov} + 0.5\cdot TY_t^{oil}}{P_{i,t}}, i = \text{nontraded}$$

$$K_t^{P,0} = \Delta K_t^{P,0} + K_{t-1}^{P,0}$$

$$K_t^{P} = \Delta K_t^{P} + K_{t-1}^{P}$$

Factor productivity growth rate

$$g_{i,t}^{p} = \varepsilon_i\left(\frac{\Delta K_t^{p}}{K_t^{p}} - \frac{\Delta K_t^{p,0}}{K_t^{p,0}}\right)$$

$$B_{i,f,t} = (1 + g_f + g_{i,t}^{p})\cdot B_{i,f,t-1}$$

A.2.3. Terminal conditions (steady-state constraints)

$$I_{k,T} = (g+\delta)\cdot V_{k,T}$$

$$(\delta + r_T)\cdot q_T = W_{k,T} + \lambda\cdot P_{i,T}\left(\frac{I_T}{V_{k,T}}\right)^2, \text{for } i = \text{nontraded}$$

The model is solved using the General Algebraic Modeling System (GAMS).

REFERENCES

Agénor, P. R., N. Bayraktar, and K. E. Aynaoui. 2008. Roads out of poverty? Assessing the links between aid, public investment, growth, and poverty reduction. *Journal of Development Economics* 86: 277–295.

Auty, R. M., ed. 2001. *Resource abundance and economic development*. UNU/WIDER Studies in Development Economics. Oxford, U.K., and New York: Oxford University Press.

Bravo-Ortega, C., and J. de Gregorio. 2005. *The relative richness of the poor? Natural resources, human capital, and economic growth*. World Bank Policy Research Working Paper No. 3484. Washington, D.C.: World Bank.

Breisinger, C., and X. Diao. 2009. Economic transformation in theory and practice: What are the messages for Africa? In *Current Politics and Economics of Africa* 1 (3/4). Hauppauge, N.Y.: Nova Science Publishers.

Breisinger, C., M. Duncan, and J. Thurlow. 2007. A social accounting matrix for Ghana. Ghana Statistical Services (GSS) and International Food Policy Research Institute (IFPRI). http://www.ifpri.org/dataset/ghana. Accessed January 21. 2010

Clemens, M. A., S. Radelet, and R. Bhavnani. 2004. *Counting chickens when they hatch: The short term effect of aid on growth*. Working Paper No. 44. Washington, D.C.: Center for Global Development.

Collier, P., and B. Goderis. 2007. *Commodity prices, growth and the natural resource curse: Reconciling a conundrum*. CSAE WPS/2007-15. Oxford, U.K.: University of Oxford.

Deaton, A. S., and R. I. Miller. 1995. International commodity prices, macroeconomic performance, and politics in Sub-Saharan Africa. *Princeton Studies in International Finance* 79.

Diao, X., and T. Roe. 2003. Can a Water Market Avert the 'Double Whammy' of Trade Reform and Lead to a 'Win-Win' Outcome? *Journal of Environmental Economics and Management* 45: 708–723.

Diao, X., and A. Somwaru. 2000. An inquiry on general equilibrium effects of MERCOSUR: An intertemporal world model. *Journal of Policy Modeling* 22(5): 557–588.

Diao, X., and E. Yeldan. 1998. Fiscal debt management, accumulation and transitional dynamics in a CGE model for Turkey. *Canadian Journal of Development Studies* 19 (2): 343–376.

Diao, X., J. Rattsø, and H. E. Stokke. 2005. International spillovers, productivity growth and openness in Thailand: An intertemporal general equilibrium model analysis. *Journal of Development Economics* 76: 429–450.

Go, D. S. 1994. External shocks, adjustment policies, and investment in a developing economy: Illustrations from a forward-looking CGE model of the Philippines. *Journal of Development Economics* 44: 229–261.

Goulder, L., and L. Summers. 1989. Tax policy, asset prices, and growth: A general equilibrium analysis. *Journal of Public Economics* 38: 265–296.

Gylfason, T., T. T. Herbertsson, and G. Zoega. 1999. A mixed blessing: Natural resources and economic growth. *Macroeconomic Dynamics* 3: 204–225.

Harberger, A. C. 2009. Reflections on oil, Dutch disease and investment decisions. Recap of presentation at the University of Ghana, June 18, 2009, Accra, Ghana.

Ho, M. S. 1989. The effects of external linkages on U.S. economic growth: A dynamic general equilibrium analysis. Unpublished Ph.D. thesis submitted to Harvard University, Cambridge, Mass.

Kaufmann, D., A. Kraay, and M. Mastruzzi. 2008. *Governance Matters VII: Governance indicators for 1996–2007*. World Bank Policy Research Working Paper No. 4280. Washington, D.C.: World Bank.

Leamer, E. E., H. Maul, S. Rodriguez, and P. K. Schott. 1999. Does natural resource abundance increase Latin American income inequality? *Journal of Development Economics* 59: 3–42.

Leite, C. A., and J. Weidmann. 1999. *Does Mother Nature corrupt? Natural resources, corruption, and economic growth*. IMF Working Paper 99/85. Washington, D.C.: International Monetary Fund.

Mazano, O., and R. Rigobon. 2006. Resource curse or debt overhand? In *Natural Resources, Neither Curse nor Destiny*, ed. D. Lederman and W. F. Maloney. Stanford, Calif.: Stanford University Press and World Bank.

Mercenier, J., and M. da C. S. de Souza. 1994. Structural adjustment and growth in a highly indebted market economy: Brazil. In *Applied General Equilibrium Analysis and Economic Development*, ed. J. Mercenier and T. Srinivasan. Ann Arbor, Mich.: University of Michigan Press.

Murshed, S. M. 2004. When does natural resource abundance lead to a resource curse? Institute for Social Studies, The Hague, the Netherlands. Mimeo.

Osei, R. D., and G. Domfe. 2008. *Oil production in Ghana: Implications for economic development*. ARI 104/2008. Accra, Ghana: Institute of Statistical Social and Economic Research, University of Ghana.

Raddatz, C. 2007. Are external shocks responsible for the instability of output in low-income countries? *Journal of Development Economics* 84: 155–187.

Rajan, R. G., and A. Subramanian. 2005. *Aid and growth: What does the cross-country evidence really show?* IMF Working Paper WP/05/127. Washington, D.C.: International Monetary Fund.

Rodrik, D. 2009a. *The real exchange rate and economic growth*. Brookings Papers on Economic Activity, Spring 2009. Washington, D.C.: Brookings Institution.

________. 2009b. Growth after crisis. http://www.growthcommission.org/storage/cgdev/documents/financial_crisis/rodrikafterthecrisis.pdf. Accessed March 2010.

Sachs, J. D., and A. M. Warner. 1995. *Natural resource abundance and economic growth*. NBER Working Paper No. 5398 (revised 1997, 1999). Cambridge, Mass.: National Bureau of Economic Research.

________. 1999. The big push, natural resource booms and growth. *Journal of Development Economics* 59: 43–76.

________. 2001. The curse of natural resources. *European Economic Review* 45: 827–838.

Sala-i-Martin, X., and A. Subramanian. 2003. Addressing the natural resource curse: An illustration from Nigeria. NBER Working Paper No. 9804. Cambridge, Mass.: National Bureau of Economic Research.

Van der Ploeg, F. 2007. Challenges and opportunities for resource rich economies.

http://www.economics.ox.ac.uk/members/rick.vanderploeg/wp-ncludes/js/tinymce/resource%20curse%20survey.pdf

Wilcoxen, P. J. 1988. The effects of environmental regulation and energy prices on U.S. economic performance. Unpublished Ph.D. thesis submitted to Harvard University, Cambridge, Mass.

World Bank. 2010. *World Development Indicators 2009*. Washington, D.C.: World Bank.

World Bank and International Monetary Fund. 2009. *Joint IMF and World Bank debt sustainability analysis*. Washington, D.C.: World Bank and International Monetary Fund.

RECENT IFPRI DISCUSSION PAPERS

For earlier discussion papers, please go to http://www.ifpri.org/publications/results/taxonomy%3A468.
All discussion papers can be downloaded free of charge.

966. *Biofuels and economic development in Tanzania.* Channing Arndt, Karl Pauw, and James Thurlow, 2010.

965. *Weathering the storm: Agricultural development, investment, and poverty in Africa following the recent food price crisis.* Babatunde Omilola and Melissa Lambert, 2010.

964. *Who has influence in multistakeholder governance systems? Using the net-map method to analyze social networking in watershed management in Northern Ghana.* Eva Schiffer, Frank Hartwich, and Mario Monge, 2010.

963. *How to overcome the governance challenges of implementing NREGA: Insights from Bihar using process-influence mapping.* Katharina Raabe, Regina Birner, Madhushree Sekher, K.G. Gayathridevi, Amrita Shilpi, and Eva Schiffer, 2010.

962. *Droughts and floods in Malawi: Assessing the economywide effects***.** Karl Pauw, James Thurlow, and Dirk van Seventer, 2010. b

961. *Climate change implications for water resources in the Limpopo River Basin*. Tingju Zhu and Claudia Ringler , 2010.

960. *Hydro-economic modeling of climate change impacts in Ethiopia*. Gene Jiing-Yun You and Claudia Ringler, 2010.

959. P*romises and realities of community-based agricultural extension.* Gershon Feder, Jock R. Anderson, Regina Birner, and Klaus Deininger, 2010.

958. R*ethinking the global food crisis: The role of trade shocks*. Derek D. Headey, 2010.

957. F*emale participation in African agricultural research and higher education - New insights: Synthesis of the ASTI–award benchmarking survey on gender-disaggregated capacity indicators.* Nienke M. Beintema and Federica Di Marcantonio, 2010.

956. Short- *and long-term effects of the 1998 Bangladesh Flood on rural wages.* Valerie Mueller and Agnes Quisumbing, 2010.

955. *Impacts of the triple global crisis on growth and poverty in Yemen*. Clemens Breisinger, Marie-Helen Collion, Xinshen Diao, and Pierre Rondot, 2010.

954. *Agricultural growth and investment options for poverty reduction in Nigeria*. Xinshen Diao, Manson Nwafor, Vida Alpuerto, Kamiljon Akramov, and Sheu Salau, 2010.

953. Micro-*level practices to adapt to climate change for African small-scale farmers: A review of selected literature.* Till Below, Astrid Artner, Rosemarie Siebert, and Stefan Sieber, 2010.

952. *Internal migration and rural service provision in Northern Ghana*. Fleur Wouterse, 2010.

951. *Implications of avian flu for economic development in Kenya*. James Thurlow, 2010.

950. *Is SAFTA trade creating or trade diverting? A computable general equilibrium assessment with a focus on Sri Lanka*. Antoine Bouët, Simon Mevel, and Marcelle Thomas, 2010.

949. *Who should be interviewed in surveys of household income*? Monica Fisher, Jeffrey J. Reimer, and Edward R. Carr, 2010.

948. *Breaking the norm: An empirical investigation into the unraveling of good behavior*. Ruth Vargas Hill, Eduardo Maruyama, and Angelino Viceisza, 2010.

947. *Agricultural growth, poverty, and nutrition in Tanzania*. Karl Pauw and James Thurlow, 2010.

946. *Labeling genetically modified food in India: Economic consequences in four marketing channels*. Sangeeta Bansal and Guillaume Gruère, 2010.

945. *Toward a typology of food security in developing countries*. Bingxin Yu, Liangzhi You, and Shenggen Fan, 2010.

944. *Paving the way for development? The impact of transport infrastructure on agricultural production and poverty reduction in the Democratic Republic of Congo.* John Ulimwengu, Jose Funes, Derek Headey, and Liangzhi You, 2009.

943. *Formal–informal economy linkages and unemployment in South Africa*. Rob Davies and James Thurlow, 2009.

942. *Recent food prices movements: A time series analysis*. Bryce Cooke and Miguel Robles, 2009.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

www.ifpri.org

IFPRI HEADQUARTERS

2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA

P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6172500
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI

CG Block, NASC Complex, PUSA
New Delhi 110-012 India
Tel.: 91 11 2584-6565
Fax: 91 11 2584-8008 / 2584-6572
Email: ifpri-newdelhi@cgiar.org