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Oil revenues for public investment in Africa: targeting urban or rural areas?

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Abstract:
This paper investigates the effects of oil financed public investment on poverty using a dynamic multisectoral general equilibrium model featuring inter-temporal productivity spillovers, which may exhibit a sector-specific and regional bias. In general, the results bear out the expectation that a surge of oil revenues leads to a real appreciation, distorting incentives which favor nontradable activities over export agriculture and manufacturing thereby increasing rural and national poverty. Whereas this result is familiar from other recent studies, the simulations show that beyond the short run, when conventional demand-side Dutch disease effects are present, the relationship between resource-rent flows and real exchange rates, output growth, and poverty is less straightforward than simple models of the "resource curse" suggest. Taking Ghana as a stylized agriculture-based economy with poverty most pronounced in a region with home biased agricultural production, a policy mix of smoothing the real exchange rate shock and an allocation of infrastructure spending in rural areas seems to be the most promising public investment strategy to enhance growth and reduce poverty.

Keywords: oil revenue, public investment, productivity, Africa, agricultural development, poverty

JEL classification: H4, O5, Q3

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I. Introduction

The limited success of "Washington Consensus" type reforms in promoting growth and reducing poverty has reemphasized the importance of a more active role of the state in development (World Bank 2005; Rodrik 2007; Lin 2010). A more active role can entail enhancing budget neutral reforms, such as improvements in legislation, regulations and rules to attract private investments. It can also imply the scaling-up of public spending, either related to shifts in existing budgets and/or through acquiring additional resources. There is broad consensus in the development economics literature that especially productivity-enhancing public investments to support private-sector led are key for growth and job creation (Syrquin 1988; World Bank 1993; Collier 2006; Breisinger and Diao 2009).

However, scaling up of public investments raises important questions on the fiscal implications and institutional requirements to translate additional resources into development outcomes. Additional financial resources for public investments can come from a variety of sources, including domestic sources (taxes) or foreign inflows (grants, bonds, resource rents). For many African countries, the possibilities of raising additional income is restricted to grants and revenues from natural resources given the generally limited scope for tax increases and limited access to international financial markets. However, several African countries are experiencing or are about to experience a surge in foreign inflows. For example, in Ghana and Uganda oil has been discovered, which is expected to significantly boost government incomes.

Yet, using such foreign exchange inflows to finance public investments can have adverse implications for development. Empirical evidence of whether foreign inflows are good or bad for growth is inconclusive. While Sachs and Warner (1999, 2001) find that countries with high resource-exports-to-GDP ratios experience lower growth rates, other research shows that resource abundance has a neutral or even positive effect on growth (Davis 1995; Lederman and Maloney 2003). The reasons for explaining potential negative impacts on growth are twofold: a lack of absorptive and managerial capacity of overstretched public sectors and the negative impact of the windfall revenues on policy choice[1] or, alternatively, Dutch Disease

[1] Windfall income or the expectations of such income generated by a discovery of natural resources might induce the country to neglect the need for sound economic management and institutional quality (Gylfason 2001). A false sense of security might lead governments to undervalue the importance of human capital, institutional quality and long run growth (Rodriguez and Sachs 1999; Sachs and Warner 2001). In addition, adverse results may be the effect of an interplay of rent-seeking groups and weak institutions (Auty 2000).

effects in the form of reduced savings and distortions of relative prices with a bias against export oriented production.[2]

Public investment decisions are also made on the basis of their growth and poverty effect, and an important policy question is where to invest? Broadly speaking, public investments can be directed to rural or urban areas and sectors. The related debate on is perhaps best reflected in the World Development Reports (WDR) 2008 and 2009. These reports convey two rather different messages of how to accelerate growth and poverty reduction in developing countries (World Bank 2008; World Bank 2009). The WDR 2008 sees "agriculture as a vital development tool for achieving the Millennium Development Goals (MDGs)", while the WDR 2009 concludes that "Growing cities, ever more mobile people, and increasingly specialized products are integral to development".

The WDR 2009 argues that in leading (often urban) areas, investment in places should be emphasized—durable investments that increase national economic growth (World Bank 2009). The rationale behind this is that high population densities lead to agglomeration effects and industrial clustering, thereby increasing innovation and productivity. According to this line of thought, public investments need to focus on increasing density, i.e. managing urban expansion and congestion by connecting different parts of a city. However, much of the empirical evidence suggests that agriculture-led growth has large multiplier effects, is most poverty reducing , and has high returns to investment, especially in African countries (World Bank 2008; Diao 2008). Evidence from China and Uganda shows that it is often the low-cost types of infrastructure that have highest returns to investment in terms of growth and poverty reduction (Fan and Zhang 2004). In the case of China, rural road investment contributes not only to rural growth and poverty reduction, but also to growth and poverty reduction in urban areas. The spatial allocation of public investments also often matters. Evidence for China, India, Thailand, and Vietnam indicates that most types of investments in less-developed areas offer the largest poverty reduction per unit of spending and the highest economic returns (Fan et al.; 2008; Fan et al. 2000; Fan and Zhang 2004; Mogues et al. 2008).

There are only few analytical attempts to compare public investments in urban and rural areas. Dorosh and Thurlow find for Uganda that improving agricultural productivity generates more

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[2] Recent publications present evidence that natural resources diminish the need for investment and savings because of the expected future income (Gylfason and Zoega 2006). Hence, at least part of the windfalls will be consumed and expectations about additional economic growth driven by the full extent of the windfall spend for investment may be exaggerated (see, e.g., Sachs and Warner 1997, Edwards 1989, Brunstad and Dyrstad 1997, Bjørnland 1998, Hutchinson 1994, Usui 1997 and Jahan-Parvar and Mohammadi 2009).

broad-based welfare improvements in both rural and urban areas than investing in the capital city. While investing in Kampala accelerates economic growth, it has little effect on other regions' welfare because of the city's weak regional growth linkages and small migration effects (Dorosh and Thurlow 2009). Evidence from Peru suggests that investing in the leading (more urbanized) region Peru may undermine the economy in the lagging (mostly rural) region by increasing import competition and internal migration (Thurlow et al. 2008). The study also shows that for reducing the divergence between the leading and lagging region, investing in the lagging region's productivity through extension services and improved rural roads is critical. This brief overview of the literature suggests that public investments in rural areas and agriculture are critical parts of development strategies in Africa. Yet, scaling up investments in either rural or urban areas is often complicated by the fact that financial resources come as foreign inflows, a fact not often captured in the literature.

To address this gap, we choose Ghana as a stylized agriculture based economy and its newly discovered oil as an example for scaling up of public investments that are based on foreign exchange inflows. To jointly assess the macroeconomic, growth, spatial and poverty impacts of rural versus urban biased investment strategies, we use a dynamic computable general equilibrium model. Ghana is a good case study for several reasons. Current conditions in Ghana seem favorable to avoiding the resource curse caused by institutional and/or political factors. Ghana's economic structure is also comparable to many other African countries. Agriculture plays an important role for the economy and contributes about one-third of total GDP. Agricultural exports are concentrated in one crop (cocoa), which, together with gold, constitutes more than 60 percent of total exports. 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; 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 reduce poverty are high.

II. The Simulation Model

Methodologically, our work is closest in spirit to Adam and Bevan (2006), who investigate the supply-side impact of aid-financed public expenditure if public infrastructure generates an intertemporal productivity spillover, which may exhibit an export or domestic bias. Given the emphasis of the paper on income distribution and poverty, the main distinguishing feature of our model is its detailed representation of agricultural production in different agro-ecological zones and of the extended functional distribution of income that takes into account informal production activities in agriculture. In addition, we explicitly link government infrastructure spending and productivity changes.

Private production and consumption

Producers and consumers are assumed to enjoy no market power in world markets, so the terms of trade are independent of domestic policy choices. Firms in each of the 15 sectors and agricultural subsectors (see Table 1) are assumed to be perfectly competitive, producing a single good that can be sold to either the domestic or the export market.[3] Production in each sector *i* is determined by a CES production function of the form:

(1) $Q_i = A_i \cdot \Sigma_f\{\delta_{fi} \cdot F_{fi}^{-\rho i}\}^{-1/\rho i}$

where *f* is a set of factors consisting of land, different types of capital and different labor categories, Q_i is the sectoral activity level, A_i the sectoral total factor productivity, F_{fi} the quantity of factor f demanded from sector *i*, and δ_{fi} and ρ_{fi} are the distributional and elasticity parameters of the CES production function, respectively. The model considers different types of labor forces, such as self-employed agricultural workers, unskilled workers employed in both agriculture and non-agriculture, and skilled non-agricultural workers. Only production in the rural food and cash crop sectors (cereals, root crops, other staple crops, and cocoa) requires land with overall supply fixed in perpetuity. Private sector capital endowments are fixed in each period but evolve over time through depreciation and investment. Land markets within each agro-ecological region and labor markets for skilled and unskilled labor are competitive so that these factors are employed in each sector up to the point that they are paid the value of their marginal product. However, capital is assumed to be sector-specific and

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[3] Appendix Tables 1 and 2 provide some indicators on the export orientation of individual sectors and the import dependence of domestic demand, together with information on sectoral and regional production, employment and cost structure. Besides mining, cocoa, forestry and livestock are the most export oriented sectors, exporting between 25 and 85 percent of their production, with the bulk of export production stemming from agro-ecological zones 1 to 3 while the poor zone 4 (Northern savanna) is producing almost exclusively for the domestic market.

immobile within each period, earning a quasi-rent in the short term while sectoral rental rates adjust to the economy-wide average rental rate in the long term. Self-employed agricultural workers are assumed to be sector-specific and immobile, both in the short and long term. Their remuneration is determined by demand rather than the marginal value product. Whenever demand slackens, lower product prices will immediately reduce income of these workers. Finally, we assume that total sector factor productivity A_i depends on the availability of public infrastructure. This detailed sector and regional structure allows the DCGE model to analyze sector and sub-sector specific growth strategies and their contribution to income distribution.

Table 1 — Classification of the CGE Model

Activities/Goods and Services	Production Factors	Economic Agents
Agriculture, partly informal diff. by 4 agro-ecological zones	4 self-employed immobile rural labor types	90 households by regional affiliation and income deciles
• Cereals	• Self-employed1	50 urban, 40 rural
• Root crops	• Self-employed2	• Accra
• Staple crops	• Self-employed3	• Urban coast
• Cocoa	• Self-employed4	• Urban forest
• Livestock	2 mobile labor types	• Urban south
• Forestry	• Skilled labor	• Urban north
• Fishing	• Unskilled labor	• Rural coast
Non-Agriculture	2 capital types	• Rural forest
• Gold mining	• Non-agr. capital	• Rural south
• Other mining	• Services capital	• Rural north
• Food processing	4 agro-ecological regions	Government
• Other manufacturing	• Land (coast)	Rest of the world
• Construction	• Land (forest)	
• Utilities	• Land (South. savanna)	
• Private services	• Land (North. savanna)	
• Public services		

The distributional consequences of external shocks and public policies are tracked through their impact on 90 household types differentiated by regional affiliation and income levels (see Table 1).

Consumption for each household type is defined by a constant elasticity of substitution linear expenditure system, which allows for the income elasticity of demand for different goods to deviate from unity. The income elasticity is estimated from a semi-log inverse function suggested by King and Byerlee (1978) and based on the data of GLSS 5 (2005-06). The estimated results, together with the average budget share for each individual commodity consumed by each individual household group determine the marginal budget shares applied in the model.

There are several alternative approaches to the analysis of the poverty effects of policy changes and exogenous shocks in CGE models (see e.g. Roland-Holst 2004). A popular approach in the CGE literature consists in specifying a relatively large number of homogenous household groups and calculating average income for each group following a shock and treating the group as a whole as being poor if average income is lower than a given poverty line. This is the procedure followed, for instance, by Adelman and Robinson (1978), in their pioneering CGE analysis of income distribution in Korea.[4] Here, the poverty effects of shocks are rather assessed by linking the simulation results of the CGE model to the results of the 2005-06 Ghana household survey (GSS 2008).

Macroeconomic closure and dynamics

The model has a neoclassical closure in which total private investment is constrained by total savings net of public investment, where household savings propensities are exogenous. This rule, broadly consistent with conditions in poorer countries where unrationed access to world capital markets is virtually zero and domestic private saving is relatively interest inelastic, means that any shortfall of government savings relative to the cost of government capital formation, net of exogenous foreign savings, directly crowds out private investment (and excess of government savings directly crowds in private investment).

The model has a simple recursively dynamic structure. Each solution run tracks the economy over 20 periods (from 2008 to 2027) from the initial policy change, each period may be thought of as a fiscal year. Within-year public and private capital stocks are fixed, and the model is solved given the parameters of the experiment (e.g., the change in oil revenues and the corresponding public expenditure response). This solution defines a new vector of prices and quantities for the economy, including the level of public and private-sector investment, which feed into the equations of motion for sectoral capital stocks:

(2) $$K_{i,t} = K_{i,t-1}(1-\mu_i) + \Delta K_{i,t-j}$$

where $K_{i,t}$ is the capital stock, μ_i denotes the sector-specific rate of depreciation, and t-j measures the gestation lag on investment.

4 Recently, Rutherford et al. (2004) have constructed a model for Russia that endogenously includes over 55,000 households.

The final element is an externality resulting from public investment in infrastructure, health, education, and agriculture. Public investment is assumed to generate a Hicks-neutral improvement in total factor productivities. Specifically, equation (1) above assumes that $A_{i,t} = A_i$ for non-spillover sectors, while in the spillover sector, denoted *s*, total factor productivities evolve according to

$$(3)\ A_{s,t} = \underline{A}_s \cdot \Pi_g\{(K^g_t/K^g_0)/(Q_{s,t}/Q_{s,0})\}^{\rho_{sg}}$$

where *g* denotes a set of public capital stocks defined over infrastructure, health, education, and agriculture, K^g, and Q_s, are the public capital stocks and sectoral output levels under the simulation experiment, and K^g_0, and $Q_{s,0}$ are the correspondingly defined public capital stocks and output levels in the base period. The terms ρ_{sg} measure the extent of the spillovers. If $\rho_{sg} = \rho_{s,} = 0$, there is no spillover from public investment in infrastructure, health, education, and agriculture. The higher ρ_{sg}, the higher are spillovers.

III. Macroeconomic Implications of Alternative Spending Scenarios

The core simulations are presented in Table 2.[5] The DCGE model is first applied to a scenario (labeled BASE) in which the sectoral level growth rate is consistent with the growth trends observed in Ghana in recent years (between 2001 and 2007). Newly found oil is not considered in this scenario. Along this business as usual growth path, the model is calibrated to feature Ghana's recent (non-oil) economic development reflected by annual economic growth of 5 percent over the next 20 years until 2027. As located off-shore and demanding equipments and expertise not yet available in Ghana, the extraction of oil will not generate significant backward linkages in terms of demand for domestic inputs and upstream activities in the short to medium term. And unlike gas, forward linkages and related downstream activities are also expected to be minimal, but through their impact on the budget (World Bank 2009). We therefore choose not to introduce a domestic oil producing activity in the model. Rather, we assume that the main impact from oil will occur through an increase in foreign exchange revenues to the government.

[5] For each simulation, the impact effect (years 2008-10) and the evolution of the economy until years 2015, 2020, and 2027 are reported. To simplify the presentation, the focus is on changes in only a small number of key aggregates: the trade weighted real exchange rate, the volume of exports, real GDP, private investment, the fiscal balance, the aggregated sectoral real value added, rural and urban household welfare measured by the equivalent variation (Table 1) and the incidence of poverty (poverty headcount; Table 2). Additional Tables in the Appendix report on the disaggregated factor income distribution, poverty depth, and poverty severety.

Given these assumptions, there is some modest structural change shown by the average sectoral growth rates in Table 2. As can be seen, the agricultural sector grows less than the industry and the service sectors. At the same time, there is also a modest real devaluation of about 5 percent over the 20 years simulation period (Figure 1). These results are driven by exogenous increases in labor and land supply, endogenously determined capital accumulation, and exogenously defined total factor productivity parameters, which reflect relatively low total factor productivity growth in agriculture compared to, e.g., construction. As a consequence, the Balassa-Samuelson effect is reversed due to weak performance of the tradable goods sectors.[6]

Six scenarios, labelled OIL1 through OIL6, contain alternative assumptions about productivity spillovers, complementary spending, and smoothing of public spending on infrastructure investment financed by the windfall gains from oil. Oil inflows start in 2010 and amount to a foreign exchange inflow of 8 percent of nominal GDP and 24 percent of government revenue in the base run.[7] In all cases the oil revenues are used exclusively to finance an increase in public infrastructure investment, holding tax rates and all other components of public expenditure, except O&M expenditure in OIL5, constant. As can be seen in Table 2, the effects on private investment differ between the OIL scenarios. This is basically due to two effects. First, the government in this model is a net seller of foreign exchange and, hence, a real exchange rate appreciation reduces the domestic value of the budget balance and therefore increases domestic financing requirements and crowding out of private investment. Second, investment is based on inputs from heavy manufacturing and the construction sector, with the latter being a pure nontradable sector. Hence, investment demand has strong price effects and corresponding general equilibrium effects also modify the outcome for private investment. Third, different assumptions about productivity effects of investment also impact on private demand for investment goods.

[6] For a similar result in the case of home driven productivity increases, see, e.g. Adam and Bevan (2006).

[7] For details, see Breisinger et al. (2009). The simulations neglect the phasing in and out of the actually expected stream of Government revenue, which consists of two successive temporary increases in foreign exchange revenues to the government, yielding four years of peak revenue, to be followed by a continues decline of revenue afterwards (World Bank 2009).

Table 2 — Simulation Results of the Effects of a Temporary Increase in Government Oil Revenues (percent)

Public investment bias	Period	BASE	OIL1	OIL2 Non-Agri	OIL3 Neutral	OIL4 Region4	OIL5 Neutral	OIL6 Neutral
Prices and quantities								
Export weighted real	2008-10	100.8	89.2	89.2	89.2	89.2	89.2	92.6
exchange rate index	2008-15	103.7	100.9	102.0	98.9	99.9	97.6	99.4
(Pt/Pd)	2008-20	105.0	105.5	106.4	103.6	104.5	102.4	103.3
	2008-27	105.2	108.0	108.8	106.2	107.0	105.1	105.5
Total exports	2008-10	5.9	-6.7	-6.7	-6.7	-6.7	-6.7	-2.8
	2008-15	5.6	3.9	5.2	6.0	5.6	5.6	6.4
	2008-20	5.4	5.1	5.9	6.3	6.1	6.0	6.3
	2008-27	5.1	5.3	5.8	6.0	5.9	5.9	6.0
Real GDP	2008-10	5.4	5.7	5.7	5.7	5.7	5.7	5.7
	2008-15	5.2	6.2	6.9	7.2	7.1	7.1	7.0
	2008-20	5.1	5.9	6.3	6.5	6.4	6.4	6.4
	2008-27	5.0	5.5	5.8	5.9	5.9	5.9	5.9
Investment	2008-10	5.7	2.2	2.2	2.2	2.2	2.2	3.8
	2008-15	5.3	6.6	8.0	8.2	8.1	7.5	8.7
	2008-20	4.9	6.4	7.2	7.4	7.3	7.0	7.7
	2008-27	4.2	5.6	6.1	6.3	6.2	6.1	6.6
Budget balance	2008-10	0.2	-1.6	-1.6	-1.6	-1.6	-1.6	-0.9
(percent of GDP)	2008-15	0.3	1.0	1.8	1.6	1.7	0.9	1.6
	2008-20	-0.2	1.7	2.5	2.5	2.5	1.8	2.2
	2008-27	-1.8	1.0	1.8	1.8	1.8	1.3	1.5
Equivalent variation								
Rural	2008-10	8.6	13.8	13.8	13.8	13.8	13.8	12.0
	2008-15	34.6	36.8	41.2	46.9	45.4	46.6	46.4
	2008-20	67.3	70.7	76.6	84.1	82.3	83.6	83.5
	2008-27	127.8	133.2	141.6	152.4	150.1	151.6	151.6
Urban	2008-10	11.5	20.5	20.5	20.5	20.5	20.5	17.5
	2008-15	46.3	53.7	59.5	62.7	61.5	63.2	60.9
	2008-20	90.7	101.8	110.3	113.9	112.5	113.7	111.7
	2008-27	173.7	190.8	203.6	208.4	206.6	207.5	205.8
Total	2008-10	10.2	17.4	17.4	17.4	17.4	17.4	14.9
	2008-15	40.8	45.8	51.0	55.3	53.9	55.4	54.1
	2008-20	79.8	87.3	94.5	100.0	98.4	99.6	98.5
	2008-27	152.2	163.8	174.5	182.1	180.1	181.3	180.4
Real value added								
Agriculture	2008-10	4.5	0.5	0.5	0.5	0.5	0.5	1.7
	2008-15	4.5	3.8	4.2	6.2	5.8	6.1	6.4
	2008-20	4.5	4.2	4.4	5.7	5.4	5.7	5.8
	2008-27	4.5	4.4	4.5	5.4	5.3	5.4	5.4
Industry	2008-10	5.7	10.9	10.9	10.9	10.9	10.9	9.7
	2008-15	5.4	8.3	9.1	8.9	8.9	8.3	8.2
	2008-20	5.2	7.1	7.6	7.4	7.5	7.1	7.1
	2008-27	4.9	6.1	6.5	6.4	6.4	6.2	6.2
Services	2008-10	5.9	3.6	3.6	3.6	3.6	3.6	4.2
	2008-15	5.8	5.7	6.6	6.1	6.2	6.5	6.1
	2008-20	5.7	6.0	6.5	6.2	6.2	6.3	6.1
	2008-27	5.5	5.8	6.2	6.0	6.0	6.0	5.9

Source: Authors' analysis based on the model described in the text

In OIL1, the infrastructure investment increases the economy's total capital stock but has no effect on private total factor productivity. In the short-run, oil inflows lead to a 10.8 percent appreciation of the real exchange rate and a sizable contraction in exports of 6.7 percent in favor of higher production of domestic goods (see Figures 1 and 2). The rising capital stock ensures that the initial decline in export performance is reversed. Especially the construction sector attracts both capital and labour. In the long run, the resulting supply effect even outperforms the initial demand effect driven by additional public infrastructure investment. As shown in Table 2, additional growth of about 0.5 percentage points on average in the long-run, i.e. from 2008 to 2027, is driven by an increase in the growth of investment spending from 2.2 to 5.6 percent. At the same time, there is almost no impact on total exports and additional home driven growth takes place in the industry and service sectors while growth in agriculture is even (slightly) reduced.

Figure 1 — Trade Weighted Real Exchange Rate Response to Oil-Financed Public Investment (Pt/Pd)

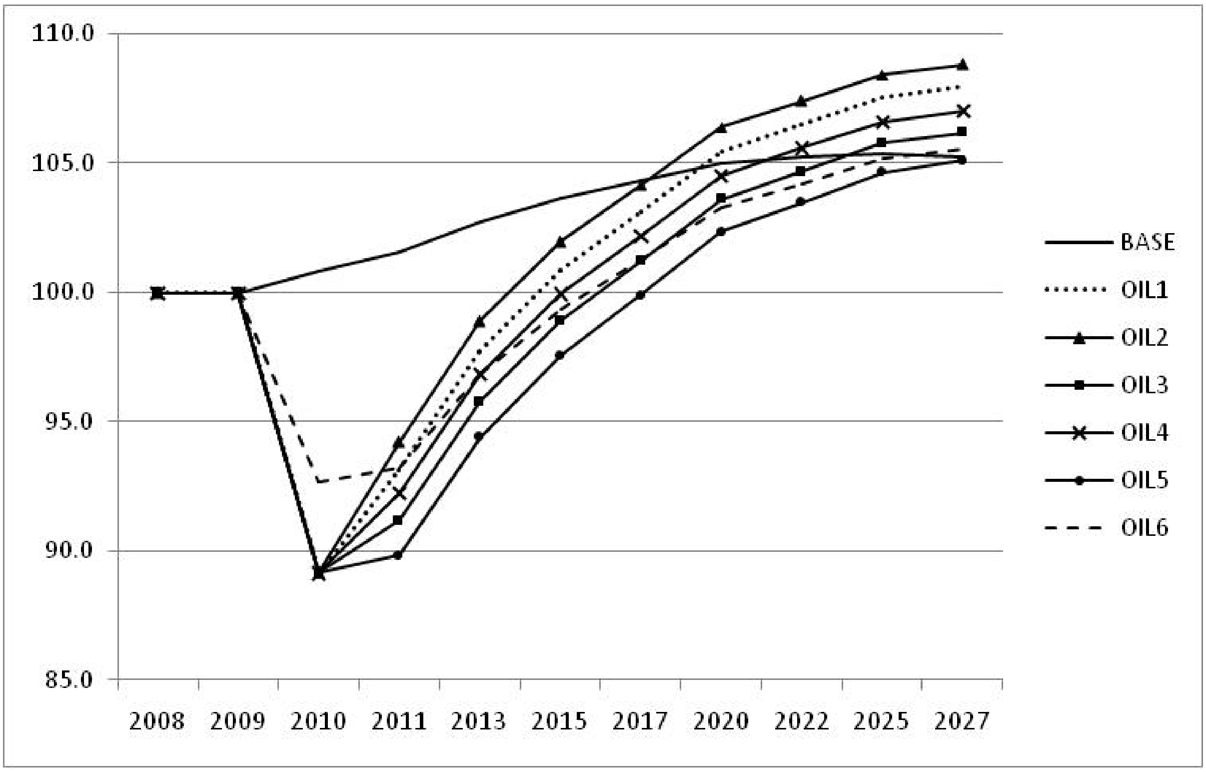
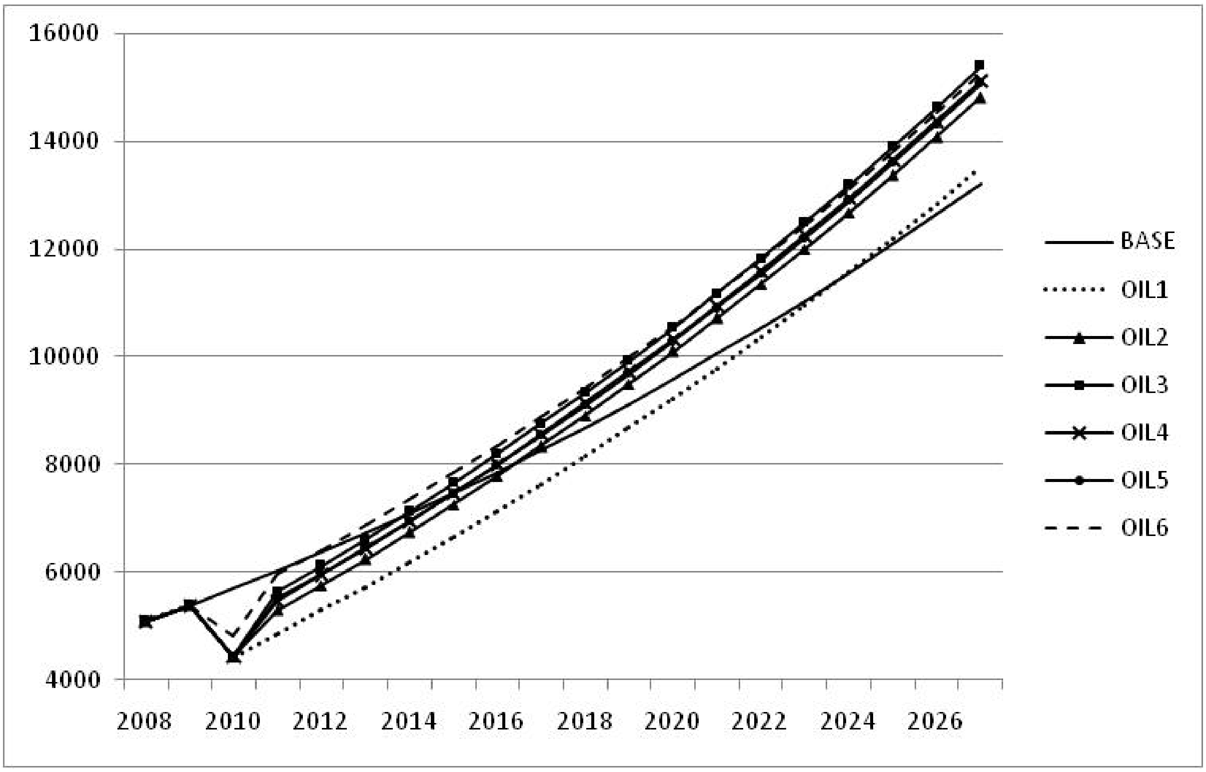


Figure 2 — Total Export response to Oil-Financed Public Investment



Contrary to OIL1, scenarios OIL2 through OIL6 assume that infrastructure investment enhances private-sector productivity. In terms of equation 2, this means that the public capital stock K^g, varies depending on the type of government infrastructure investment. Together with the spillover parameter ρ_{sg}, it determines the extent of the sectoral productivity effect. There is little consensus on the size of the productivity effects of infrastructure investment in low-income countries. The assumed value for this parameter is $\rho_{sg,}$ = 0.5 for industrial and the private services sector, comparatively higher than the values estimated in Hulten's (1996) study of infrastructure capital and economic growth. This higher baseline value reflects the expectation of a higher marginal product of public capital for countries with a severely depleted capital stock. It is also closer to the value of comparable parameters that have been estimated for agriculture in Ghana. For all rural areas in Ghana, the marginal effect of public agricultural investment spending has been estimated by Benin et al. (2008) at 0.54.

OIL2 through OIL4 scenarios vary in terms of the allocation of infrastructure investment:

- OIL2 applies the current bias in public investment spending pattern against agriculture. Here, only 5.2 percent of overall public development spending is used to finance agricultural infrastructure while about 94.8 percent is allocated to urban infrastructure investment.

- OIL3 assumes that the spending pattern is neutral and government now spends 33 percent (instead of 5.2 percent) of oil revenues for investment in agricultural infrastructure while only 67 percent are allocated to non-agriculture. This reflects the share of agricultural in total value added.

- OIL 4 assumes the same spending pattern between agriculture and non-agriculture as OIL3 but one that is biased within agriculture towards productivity-enhancing agricultural infrastructure in the north of Ghana, which has the highest poverty rates.

There is now fairly substantial compound growth in GDP over the 20 years, some improvement in the fiscal balance, and a marked increase in private investment.[8] As a consequence, while the impact effects on the real exchange rate and on exports are identical to those in OIL1, because of the time lag before the productivity effects kick in, the impacts diverge sharply over time. All of the real exchange rate appreciation has been unwound by the end of year 2015 (except in OIL3) and the real exchange rate is further depreciating afterwards. Moreover, even though the real exchange rate remains somewhat appreciated relative to its baseline value in the medium-run (except in OIL2), the initial 6.7 percent fall in export volumes is reversed moving to a 5.2-6.0 percent increase. Over the whole simulation period, exports growth is about 1 percentage points higher than in the base run.

Comparing these spending scenarios, it is evident that, from a macroeconomic point of view, OIL3 seems to be superior. It results in the highest growth rates in terms of trade, investment and GDP. In addition, it has the highest sectoral growth for agricultural products although real appreciation in the short and long run is clearly stronger. Hence, appreciation seems not to hurt the agricultural sector, at least, not in a way that would overcompensate the positive investment effect of a neutral allocation of public investment funds. To the contrary, scenario OIL2 with the highest level of exchange rate devaluation is in favor of the industry and

[8] Government revenue grows as real incomes and expenditures grow while, after the initial step changes in year 2010, real government spending does not. Savings available for private investment grow partly with GDP but also because of crowding-in from the improvement in the fiscal balance. It is a consequence of the closure rule mentioned earlier that these resources are duly invested.

service sectors, i.e. in favor of home based growth. At the same time, a pro-poor bias in public investment spending as in OIL4 does not have obvious macroeconomic advantages. Compared to OIL3, export expansion is less pronounced and industrial growth even benefits at the cost of agricultural production.

As a consequence, we based the OIL5 and OIL6 scenarios on the allocative assumptions of OIL3. OIL5 re-runs OIL3 but now assumes that an increased public capital stock entails a higher level of operations and maintenance (O&M) expenditure. This is calibrated on the basis of evidence on the recurrent expenditure requirements of World Bank financed capital projects compiled by Hood et al. (2002). The baseline assumption is that these additional O&M costs of 10 percent of the increase in public capital stocks are financed through increases in the domestic budget deficit, thereby crowding out private investment. As shown in Figure 1 and Table 2, the increasing current expenditures induce an extended appreciation of the real exchange rate, a decline in public savings, and, consequently additional crowding-out of private investment.

Finally, we consider in the OIL6 scenario that the government, rather than spending all oil revenues as they emerge, saves a significant share of 30 percent in an external oil fund, while only 70 percent plus the interest income earned from the fund are allocated to the government budget for financing infrastructure investment based on the neutral assumptions as in OIL3. As can be seen, the smoothing feature of building up an oil fund moderates short-run absorption effects and, hence, real appreciation. It is not surprising that OIL6 provides superior results concerning export expansion. The immediate contraction is more than halved without a loss of export dynamics in the medium run. However, smoothing oil spending also implies higher growth of private investment because, compared to OIL2-4 scenarios, the increase in the budget deficit and, hence, crowding out, is less pronounced.

All in all, from a macroeconomic point of view the alternative oil scenarios reveal different patterns for the real exchange rate and total investment while average growth rates for the medium run rather converge towards 5.2 to 6.4 percent, at least for those scenarios considering productivity spillovers. OIL2, the scenario with the strongest devaluation shows advantages in term of industrial and services sector growth, OIL 3 not discriminating against agriculture is superior in terms of medium run export, investment, and GDP growth. While a pro-poor bias in infrastructure spending has no macroeconomic advantages, smoothing oil spending improves trade dynamics by moderating the short run appreciation and the consequent contraction. In addition, the advantages of stretching oil funds beyond 2027 does not have significant repercussion: the difference in average growth compared to OIL3 ranges between 0.1 and 0.2 percentage points depending on the time horizon (Table 2).

IV. Poverty Implications of Alternative Scenarios

While total household income and welfare increase in the short and long term in all oil scenarios, compared to the base run, the gains are not distributed equally across all household groups. Rural households actually experience a decline in income and welfare relative to urban households (see Figures 3 and 4 and Table 2). The principal reason is that the demand effects from increased government and private expenditures fall disproportionately on sectors, which intensively use factors supplied by urban households, and on intermediate goods from the manufacturing and services sectors. In addition, backward linkages from urban sectors to the rural sectors are extremely weak. Thus, agriculture and rural households depending on it do not benefit significantly from increased income but are hurt by higher prices for intermediate inputs and consumer goods.

If public infrastructure investment confers no productivity spillovers, as in scenario OIL1, real agricultural value added not only declines relative to non-agricultural value added, but also absolutely compared to the base run, both in the short and long term (see Table 2). The worsening of agricultural terms of trade is also reflected in the functional distribution of income with mobile factors, such as skilled and unskilled labor improving their relative income position while the income shares of sector-specific factors employed in agriculture (self-employed workers and land) are decreasing (see Appendix Table 3). Thus, the improvement in rural household welfare shown in Table 2 is almost exclusively due to increasing wages for (inter-sectoral mobile) unskilled workers. By contrast, immobile poor rural households depending on self-employment income are largely by-passed by the income effects of additional demand but are negatively affected by higher input prices. This is reflected in the poverty indicators (see Table 3 and Appendix Tables 4-5).

Compared to the base-run, the resource boom increases the incidence, depth, and severity of poverty on a national scale, both in the short and medium term. This worsening of the poverty situation can be solely traced back to higher poverty in rural households, both in the North and non-North, while urban poverty is slightly reduced. The initial real appreciation strongly discriminates the export-oriented cocoa, forestry, and fishing sectors. Although producers of cereals, root crops, and other staple crops benefit from higher private demand, the sole beneficiaries are those rural households which predominantly earn unskilled labor income while poor households are negatively affected by lower self-employment income and lower land rentals. The situation improves and rural poverty rates move towards their base-run values in the long-run, i.e. after the year 2020 when the real exchange rate appreciation has been unwound. Hence, it is to be expected that the real exchange rate effects discussed in Chapter III have a significant impact on poverty results.

Figure 3 — Household Incomes in Response to Oil-Financed Public Investment

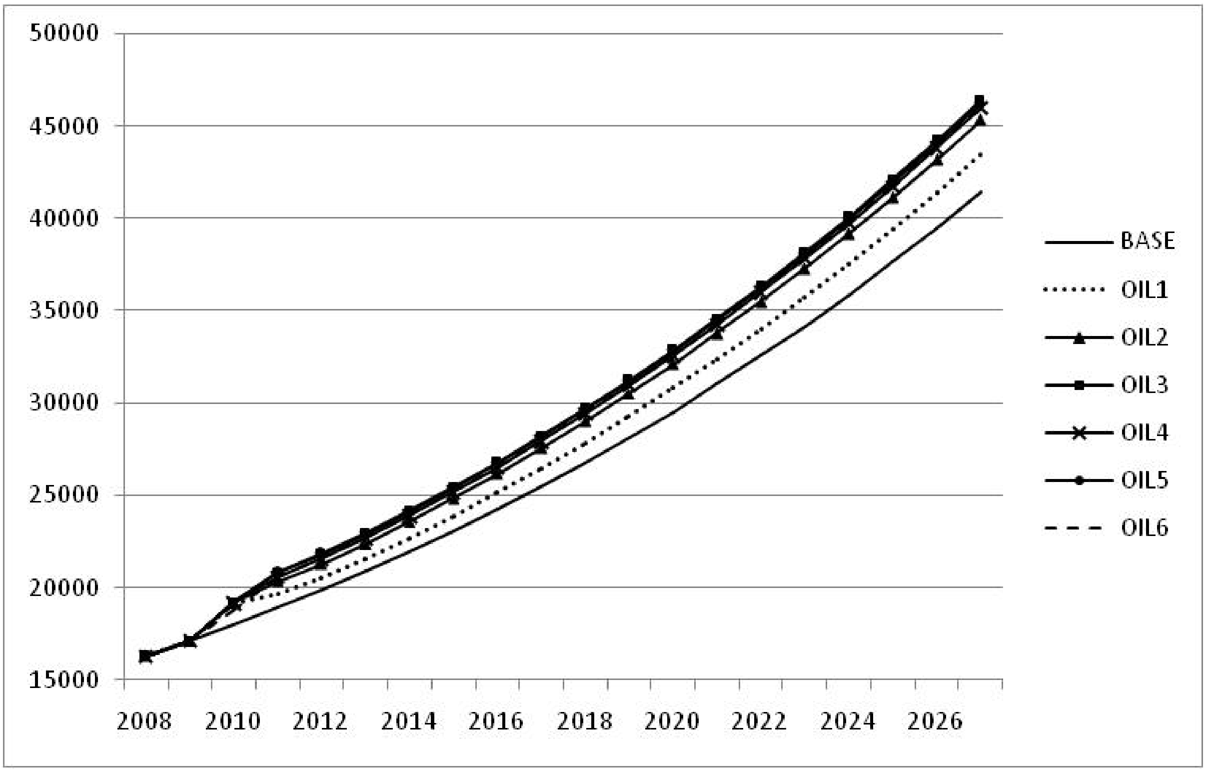
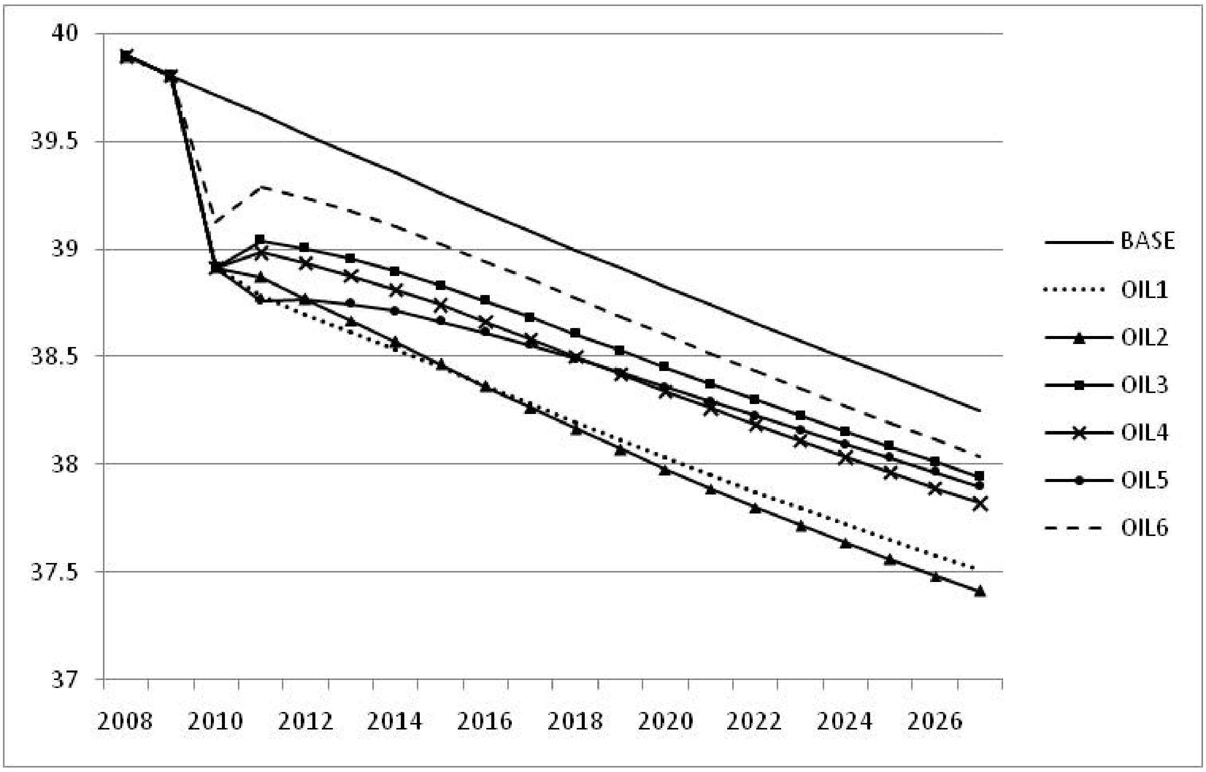


Figure 4 — Rural Share in Total Income in Response to Oil-Financed Public Investment



This is confirmed by the results for scenarios OIL2 to OIL4. With productivity spillovers, the impact effects on household incomes and welfare are the same as in the previous scenario, so that rural income again falls relative to urban income, matters now improve or worsen over time, depending on the allocation of infrastructure spending. Given the discrimination in infrastructure spending against the agricultural sector (scenario OIL2), rural households enjoy a temporary medium-term improvement in their relative income position, compared to the previous scenario, but lose ground in the long term. The bias in production towards non-agriculture (which increases the supply of nontradable goods) is sufficiently strong to more than offset the demand effects of the increased foreign exchange inflow so that the initial real exchange rate appreciation is reversed within four years. Overall export performance is stronger than without productivity effects, reflecting the real depreciation induced by the domestic bias, which makes exports more profitable. Moreover, agricultural exports recover strongly while the bias in infrastructure investment spending results in a more sluggish recovery in non-agriculture exports, and vice versa in the long term.

Table 3 — Simulation Results of the Poverty Effects of a Temporary Increase in Government Oil Revenues (Headcount)

	2008	2010	2012	2015	2020	2027
NATIONAL						
BASE	28.5	25.4	22.4	18.9	13.5	8.9
OIL1	28.5	27.2	24.3	19.7	13.8	8.8
OIL2	28.5	27.2	22.7	18.4	13.0	7.9
OIL3	28.5	27.2	18.9	15.0	10.4	6.2
OIL4	28.5	27.2	20.4	15.8	11.0	6.3
OIL5	28.5	27.2	19.7	15.4	10.8	6.4
OIL6	28.5	26.7	18.7	14.8	10.4	6.2
RURAL						
BASE	41.0	36.4	32.4	27.4	19.7	12.7
OIL1	41.0	39.9	35.6	29.2	20.4	12.8
OIL2	41.0	39.9	33.4	27.3	19.3	11.3
OIL3	41.0	39.9	28.1	22.1	15.3	8.6
OIL4	41.0	39.9	30.1	23.2	15.9	8.6
OIL5	41.0	39.9	29.3	22.7	15.9	8.8
OIL6	41.0	38.9	27.7	21.7	15.3	8.6
URBAN						
BASE	13.4	12.3	10.9	9.1	6.9	5.2
OIL1	13.4	11.6	10.9	8.6	6.5	4.8
OIL2	13.4	11.6	9.7	7.8	5.9	4.5
OIL3	13.4	11.6	7.7	6.7	5.1	4.0
OIL4	13.4	11.6	8.7	7.3	5.6	4.3
OIL5	13.4	11.6	7.9	6.9	5.2	4.2
OIL6	13.4	11.9	7.8	6.7	5.2	4.1
NORTH						
BASE	62.7	60.9	58.4	54.3	47.2	35.5
OIL1	62.7	62.2	60.7	56.3	48.0	35.5
OIL2	62.7	62.2	59.3	55.0	46.3	32.1
OIL3	62.7	62.2	55.2	49.9	40.5	25.4
OIL4	62.7	62.2	55.0	49.5	40.2	25.4
OIL5	62.7	62.2	56.1	50.3	41.6	26.1
OIL6	62.7	61.8	54.9	49.2	40.5	25.5
NON-NORTH						
BASE	19.7	16.3	13.3	9.9	5.1	2.4
OIL1	19.7	18.2	15.1	10.5	5.3	2.2
OIL2	19.7	18.2	13.3	9.1	4.7	2.0
OIL3	19.7	18.2	9.6	6.1	2.9	1.5
OIL4	19.7	18.2	11.6	7.3	3.7	1.7
OIL5	19.7	18.2	10.4	6.6	3.1	1.6
OIL6	19.7	17.6	9.5	6.0	2.9	1.5

Source: Authors' analysis based on the model described in the text

Although the income gains from higher productivity are partly transmitted to the poor, these are insufficient to compensate for the short-run income losses of poor rural households that result from the demand effects discussed above. Thus, while rural poverty is reduced over time, it still increases relative to the base run in the short to medium term (until 2014; see Table 3). The reason is that at the current allocation of public infrastructure spending, the welfare-enhancing productivity effects in agriculture do not generate sufficient agricultural growth to lift poor households, which primarily depend on self-employment income, above the poverty line. Medium term growth of agriculture real value added is still 0.3 percentage points lower than in the base run (see Table 2). In addition, the major beneficiaries of the current allocation of infrastructure spending are mobile unskilled workers whose relative income position improves while poor self-employed farmers loose against other households (see Appendix Table 3). Thus, while the current allocation of public infrastructure investment leads to a reduction of urban poverty in the short, medium, and long term, it temporarily increases rural poverty and reduces the incidence of poverty on the country-side only slightly in the long term.

Not surprisingly, the results are more pro-poor if oil-financed public infrastructure spending is allocated neutrally between agriculture and non-agriculture, as in scenarios OIL3 and OIL4, and if it is biased toward the poor Northern region within agriculture, as in scenario OIL4. As expected, when there is less increase in the productivity of less export-oriented (industrial) sectors, this leads to a more appreciated path for the export-weighted real exchange rate in both scenarios. The appreciation is less pronounced in OIL4 because the Northern region largely produces food crops (cereals, root crops, other staple crops, and livestock) for the domestic market. Hence, although agricultural export performance is stronger in both scenarios because of higher productivity growth, industrial and private services exports are hit relatively hard, compared to the OIL2-scenario, because of the extended real appreciation.

The most striking difference between these two scenarios and the previous one, though, is the effect on sectoral income distribution and poverty. A neutral allocation of infrastructure spending (OIL 3) leaves private investment and real GDP growth almost unaffected but drastically changes the sectoral distribution of value added in the medium and long term with real agricultural value added rising from 4.5 percent in the base run to 6 and 5.4 percent on average in the medium and long term (see Table 2). This change in the sectoral distribution of income is also reflected in changes in poverty indicators with the incidence of both rural and urban poverty decreasing in the medium and long term. Because agriculture is export-oriented, the increase in productivity that results from a neutral allocation of public infrastructure spending primarily leads to an output expansion, higher remuneration of self-employed workers and higher land rentals, rather than decreasing prices. Looking at the medium and long run implications for poverty, Table 3 clearly reveals that the combination of productivity spillovers and price increases curbed by world market competition yield the lowest headcounts, except for the North.

These effects are somehow moderated if public infrastructure investment is biased within agriculture toward the Northern region. As in OIL3, rural poverty is decreasing in the medium and long run, compared to the base-run scenario. While the poverty rate in the Northern region persists on its base-run value over the medium term in scenario OIL3, the headcount is reduced drastically in OIL4. However, additional poverty reduction is rather moderate. In the long run, headcount for OIL3 and OIL4 are the same. Because agriculture is home biased in the North, the economy's increased ability to produce agricultural goods shifts the domestic terms of trade in favor of those consuming the now relatively cheaper agricultural goods (both, rural and urban households) and against those producing them (rural households). Additionally, reducing poverty in the Northern region is not costless but increases urban and non-North rural poverty.

As noted above, demand-side effects imply a tendency for urban households to gain disproportionately from oil-financed increases in infrastructure because of low backward linkages from government expenditures to the rural sector of the economy. The relative price movements induced by additional recurrent public expenditures for the operation and maintenance of a higher public infrastructure capital stock (O&M expenditure) in scenario OIL5 exacerbate these weak linkages.[9] Additional recurrent spending involve a worsening of the fiscal budget, a crowding-out of private investment and a more appreciated real exchange rate as resources, particularly scarce skilled labor, are relocated from tradable sectors to the nontradable public sector. Compared to OIL3, this implies a worsening of the income distribution and higher rural poverty rates.

It is worth highlighting one important feature of the results for all scenarios discussed so far: the relative decline in rural incomes in these scenarios is immediate and persistent, as clearly shown in Figure 4. In contrast to what is happening elsewhere in the economy, it is this demand effects rather than the supply factors that drive rural incomes in both the short and the long term. This is seen very clearly from the fact that alternative public infrastructure investment patterns alter the pattern of incomes very little indeed. However, they do have

[9] Scenarios OIL4 and OIL5 assume the same infrastructure spending pattern as scenario OIL3.

implications for poverty reduction. Thus, an important element of any policy to contain increasing poverty during resource booms should be to combine policies to contain real exchange rate appreciation and measures to increase rural productivity.

Therefore, OIL6 investigates the case where part (30 percent) of the oil revenue is saved in an external resource fund while the rest as well as interest income from the fund is allocated neutrally to public infrastructure investment in agriculture and non-agriculture, as in scenario OIL3. There is now less initial appreciation of the export weighted real exchange rate, some improvement in the fiscal balance, and a marked increase in private investment. As a consequence, the short to medium term impacts diverge sharply. Virtually all of the real exchange rate appreciation has been unwound by the 2015. As a result, agricultural and export growth is much higher than in scenario OIL3. While the impact and long-term effect on household incomes is negative, so that both urban and rural incomes fall, compared to OIL3, headcounts match those of OIL3 for the years 2020 and 2027 respectively. Even more importantly, the moderation of real appreciation produces, with only one exeption, the lowest headcounts for the short run, i.e. up to 2015. For the North, the moderation of the real appreciation is even more effective in reducing poverty rates than investment targeting as in OIL4. Finally, the accumulation of savings in an oil fund allows the country to continue to enjoy the income generated from oil even after the end of the oil era, this scenario suggests that it is an option that might be the best for growth and poverty reduction in the long run.

VI. Summary and Conclusions

This paper has addressed specific questions within the much broader discussion of development financed by foreign exchange inflows in developing countries. The short to long term impacts of oil-financed public infrastructure investment in Ghana was analyzed numerically using a dynamic computable general equilibrium model featuring intertemporal productivity effects, which may exhibit a sector and regional specific bias depending on public spending schemes. The analysis was carried out on a fifteen sectors, 12 factors, and 90 households level aggregation that takes into account the structural characteristics of the Ghanaian economy, most importantly, the sectoral composition of agricultural production in four agro-ecological zones and the informal nature of large parts of agricultural production. In addition the CGE results were combined with individual household characteristics from the Ghana Living Standards Survey to calculate so-called FGT (Foster, Greer, and Thorbecke) poverty indices, which take into account the full functional and spatial diversity of household income. Several conclusions emerge from the simulations presented in this paper.

First, a resource boom and the accompanying developmental and/or recurrent public expenditures, besides direct effects, induce short and longer term general equilibrium repercussions which have large and generally negative indirect effects on agriculture as well as on rural income and poverty. However, when developmental expenditures in public infrastructure augment the productivity of private factors, and when there is an initial scarcity of public infrastructure, there are potentially large medium to long-run welfare gains from a resource boom − despite the presence of short-run Dutch disease effects − if at least part of the resource revenue is used to finance public investment.

Second, the dynamic and distributional consequences of this investment are highly sensitive to the location of productivity effects and the characteristics of demand. The presence of an industrial bias in the aggregate supply response, while broadly beneficial to the economy in terms of boosting aggregate growth and investment, welfare, and exports and moderating the appreciation of the real exchange rate, leads to an increase in the incidence of poverty in rural areas and in the poor North in the medium term while it reduces poverty only slightly over the long term, compared to the base run.

Third, across all scenarios, particularly when there is an industrial bias in public investment spending, the agricultural sectors do not share proportionately in the aggregate income gains to the economy. The economy as a whole enjoys a large medium term supply response, but at the cost of increasing rural poverty and a sharp worsening of the distribution of income between agriculture and the rest of the economy.

Fourth, a bias in infrastructure investment toward the Northern poverty region has important drawbacks. Reducing poverty via targeted investment increases rural poverty because increased productivity leads to a worsening of the terms of trade of agricultural products. In the short run, smoothing the real appreciation by investing part of the oil windfall into an oil fund is even superior in terms of poverty reduction in the North.

Finally, our results confirm other results showing little if any drawbacks in the short run while negative structural implications of spending all oil money as it becomes available has negative effects for the rural economy, the agricultural sector and, hence, poverty rates at least in the short run.

All in all, taking Ghana as a stylized agriculture-based economy with poverty most pronounced in a region with home biased agricultural production, a policy mix of smoothing the real exchange rate shock and an allocation of infrastructure spending which ends the bias against agriculture seems to be superior to other spending paths. Recognizing the importance of economic structure in determining the final sectoral, distributional and poverty effects of a resource boom also demonstrates that targeting infrastructure spending may have important drawbacks in terms of poverty reduction which may require complementary intervention.

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Appendix Table 1 — Production and Trade Structure, Ghana 2007

Sector	VAshr	PRDshr	EMPshr	EXPshr	EXP-OUTshr	IMPshr	IMP-DEMshr
Cereals	3.0	2.4	1.2			4.8	46.4
Root crops	8.1	6.6	3.5				
Staple crops	8.2	6.8	3.7	2.8	8.3		
Cocoa	5.6	4.7	2.7	20.1	85.5		
Livestock	2.5	2.3	4.1			2.7	32.3
Forestry	3.7	3.0	5.0	10.8	72.5		
Fishing	1.8	1.5	3.2	2.0	26.9		
Gold mining	7.8	6.5	3.7	30.7	97.1		
Other mining	0.4	0.4	0.3	1.5	77.5		
Food processing	3.7	5.8	5.0	5.2	18.3	12.3	50.0
Other manufacturing	6.6	12.8	7.8	8.1	12.9	75.3	72.3
Construction	10.5	7.6	10.9				
Utilities	3.3	4.5	2.7				
Private services	18.1	24.3	23.4	18.9	15.9	4.9	7.5
Public services	16.6	10.8	22.8				
Total	100.0	100.0	100.0	100.0	20.3	100.0	32.6
Agriculture	33.0	27.3	23.4	35.7	26.3	7.5	13.6
Non-Agriculture	67.0	72.7	76.6	64.3	18.1	92.5	37.3
Total	100.0	100.0	100.0	100.0	20.3	100.0	32.6

VAshr: value added share; PRDshr: production share; EMPshr: employment share; EXPshr: share in total exports; EXP-OUTshr: share of exports in sectoral production; IMPshr: share in total imports; IMP-DEMshr: share of imports in domestic demand.

Source: Ghana Social Accounting Matrix, 2007 (unpublished).

Appendix Table 2 — Output, Input, and Trade Structure of Agriculture, Ghana, 2007 (percent)

	Zone1	Zone2	Zone3	Zone4	EXP-OUTshr	IMP-DEMshr
		Structure of output			Trade	orientation
Cereals	8.9	5.8	6.4	16.7		46.4
Root crops	27.0	47.7	68.0	52.4		
Oth staple crops	46.1	33.8	20.0	27.2	8.3	
Cocoa	1.1	5.1	1.9		85.5	
Livestock	4.5	2.0	0.7	3.3		32.3
Forestry	0.4	5.3	2.1	0.2	72.5	
Fishing	12.2	0.4	0.9	0.2	26.9	
Total	100.0	100.0	100.0	100.0	26.3	13.6
		Structure of input cost				
Intermediates	39.2	36.4	36.4	43.2		
Self-empl labor	0.9	1.0	0.8	1.7		
Skilled labor	6.9	0.7	1.4	0.3		
Unskilled labor	22.3	21.8	18.4	23.0		
Agr capital	3.1	4.9	5.2	4.3		
Non-agr capital	0.0	0.0	0.0	0.0		
Services capital	0.2	0.3	0.2	0.0		
Land	27.5	34.9	37.6	27.6		
Total	100.0	100.0	100.0	100.0		

Source: Ghana Social Accounting Matrix, 2007 (unpublished)

Appendix Table 3 — Change in Disaggregated Factor Income Distribution

	INITIAL	BASE	OIL1	OIL2	OIL3	OIL4	OIL5	OIL6
2008-10								
labself1	0.05		-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
labself2	0.24		-0.03	-0.03	-0.03	-0.03	-0.03	-0.02
labself3	0.12		-0.02	-0.02	-0.02	-0.02	-0.02	-0.01
labself4	0.15		-0.02	-0.02	-0.02	-0.02	-0.02	-0.01
labskll	10.03	0.09	0.63	0.63	0.63	0.63	0.63	0.48
labunsk	42.97	0.39	0.39	0.39	0.39	0.39	0.39	0.44
capn	26.23	-0.56	1.57	1.57	1.57	1.57	1.57	0.88
caps	2.40	-0.04	0.12	0.12	0.12	0.12	0.12	0.07
land1	1.64	0.02	-0.20	-0.20	-0.20	-0.20	-0.20	-0.14
land2	8.20	0.05	-1.43	-1.43	-1.43	-1.43	-1.43	-0.99
land3	5.53	-0.03	-0.71	-0.71	-0.71	-0.71	-0.71	-0.51
land4	2.45	0.07	-0.27	-0.27	-0.27	-0.27	-0.27	-0.17
2008-15								
labself1	0.05	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
labself2	0.24	0.01	-0.01	-0.01		-0.02	-0.01	
labself3	0.12		-0.01	-0.01		-0.01	-0.01	
labself4	0.15	0.01	-0.01	-0.01	-0.01	0.01	-0.02	-0.01
labskll	10.03	0.36	0.60	0.59	0.49	0.51	1.08	0.43
labunsk	42.97	1.20	2.37	2.52	2.50	2.47	2.18	2.22
capn	26.23	-1.65	-1.53	-1.57	-2.06	-1.92	-2.08	-2.06
caps	2.40	-0.13	-0.12	-0.12	-0.16	-0.15	-0.16	-0.16
land1	1.64	0.07	-0.05	-0.03	0.09		0.06	0.11
land2	8.20	0.07	-0.75	-0.86	-0.46	-0.59	-0.58	-0.28
land3	5.53	-0.18	-0.53	-0.54	-0.50	-0.62	-0.57	-0.42
land4	2.45	0.24	0.04	0.05	0.14	0.33	0.10	0.18
2008-20								
labself1	0.05	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02
labself2	0.24	0.02	0.01		0.01	-0.01	0.01	0.02
labself3	0.12		-0.01	-0.01		-0.01		0.01
labself4	0.15	0.01		-0.01	-0.01	0.02	-0.01	-0.01
labskll	10.03	0.72	0.77	0.76	0.63	0.66	1.04	0.56
labunsk	42.97	1.76	3.52	3.81	3.67	3.66	3.33	3.35
capn	26.23	-2.46	-3.14	-3.20	-3.73	-3.59	-3.93	-3.85
caps	2.40	-0.20	-0.26	-0.27	-0.31	-0.30	-0.33	-0.32
land1	1.64	0.10	0.03	0.03	0.16	0.07	0.21	0.24
land2	8.20	0.02	-0.60	-0.78	-0.27	-0.42	-0.16	0.04
land3	5.53	-0.38	-0.58	-0.62	-0.54	-0.68	-0.60	-0.51
land4	2.45	0.42	0.28	0.28	0.41	0.61	0.45	0.51
2008-27								
labself1	0.05	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
labself2	0.24	0.03	0.02	0.01	0.02	0.02	0.02	0.01
labself3	0.12		-0.01	-0.01				
labself4	0.15	0.01						-0.01
labskll	10.03	1.36	1.22	1.21	1.06	1.40	1.08	0.63
labunsk	42.97	2.21	4.37	4.76	4.55	4.21	4.24	3.32
capn	26.23	-3.32	-4.54	-4.63	-5.17	-5.05	-4.95	-3.56
caps	2.40	-0.28	-0.39	-0.39	-0.44	-0.43	-0.42	-0.30
land1	1.64	0.15	0.10	0.11	0.22	0.21	0.22	0.17
land2	8.20	-0.10	-0.57	-0.78	-0.21	-0.25	-0.16	-0.17
land3	5.53	-0.71	-0.79	-0.85	-0.76	-0.80	-0.76	-0.51
land4	2.45	0.67	0.60	0.60	0.75	0.72	0.75	0.43

Source: Authors' analysis based on the model described in the text

Appendix Table 4 — Simulation Results of the Poverty Effects of a Temporary Increase in Government Oil Revenues (Poverty Depth)

	2008	2010	2012	2015	2020	2027
NATIONAL						
BASE	9.6	8.4	7.3	5.9	4.2	2.5
OIL1	9.6	8.9	7.9	6.3	4.3	2.4
OIL2	9.6	8.9	7.4	5.8	3.9	2.2
OIL3	9.6	8.9	6.0	4.7	3.1	1.7
OIL4	9.6	8.9	6.3	4.8	3.1	1.7
OIL5	9.6	8.9	6.3	4.9	3.2	1.7
OIL6	9.6	8.8	5.9	4.6	3.0	1.7
RURAL						
BASE	14.1	12.4	10.8	8.8	6.1	3.5
OIL1	14.1	13.5	12.0	9.5	6.4	3.5
OIL2	14.1	13.5	11.1	8.8	5.9	3.1
OIL3	14.1	13.5	9.1	7.0	4.5	2.3
OIL4	14.1	13.5	9.5	7.2	4.6	2.4
OIL5	14.1	13.5	9.6	7.4	4.7	2.4
OIL6	14.1	13.2	8.8	6.9	4.5	2.3
URBAN						
BASE	3.8	3.4	3.0	2.6	2.0	1.5
OIL1	3.8	3.1	2.9	2.5	1.9	1.4
OIL2	3.8	3.1	2.7	2.2	1.7	1.3
OIL3	3.8	3.1	2.2	1.9	1.4	1.0
OIL4	3.8	3.1	2.4	2.0	1.5	1.1
OIL5	3.8	3.1	2.3	1.9	1.5	1.1
OIL6	3.8	3.2	2.2	1.9	1.4	1.0
NORTH						
BASE	28.2	26.4	24.5	21.6	16.6	10.2
OIL1	28.2	27.9	26.2	22.7	17.1	10.1
OIL2	28.2	27.9	25.0	21.6	16.0	9.2
OIL3	28.2	27.9	22.0	18.3	12.8	7.0
OIL4	28.2	27.9	21.9	18.3	12.8	7.1
OIL5	28.2	27.9	22.7	19.0	13.2	7.2
OIL6	28.2	27.6	21.5	18.1	12.7	7.0
NON-NORTH						
BASE	4.8	3.8	2.9	2.0	1.0	0.6
OIL1	4.8	4.1	3.3	2.1	1.0	0.5
OIL2	4.8	4.1	2.9	1.8	0.9	0.5
OIL3	4.8	4.1	2.0	1.2	0.6	0.4
OIL4	4.8	4.1	2.3	1.4	0.7	0.4
OIL5	4.8	4.1	2.1	1.3	0.7	0.4
OIL6	4.8	4.0	1.9	1.2	0.6	0.4

Source: Authors' analysis based on the model described in the text

Appendix Table 5 — Simulation Results of the Poverty Effects of a Temporary Increase in Government Oil Revenues (Poverty Severety)

	2008	2010	2012	2015	2020	2027
NATIONAL						
BASE	4.6	4.0	3.4	2.7	1.8	1.0
OIL1	4.6	4.2	3.7	2.9	1.9	1.0
OIL2	4.6	4.2	3.4	2.7	1.7	0.9
OIL3	4.6	4.2	2.8	2.1	1.3	0.7
OIL4	4.6	4.2	2.9	2.2	1.3	0.7
OIL5	4.6	4.2	2.9	2.2	1.4	0.7
OIL6	4.6	4.2	2.7	2.1	1.3	0.7
RURAL						
BASE	6.9	6.0	5.1	4.1	2.7	1.5
OIL1	6.9	6.5	5.7	4.4	2.9	1.5
OIL2	6.9	6.5	5.3	4.1	2.6	1.3
OIL3	6.9	6.5	4.2	3.2	2.0	0.9
OIL4	6.9	6.5	4.4	3.3	2.0	1.0
OIL5	6.9	6.5	4.5	3.4	2.0	1.0
OIL6	6.9	6.3	4.1	3.1	1.9	1.0
URBAN						
BASE	1.6	1.4	1.3	1.1	0.8	0.6
OIL1	1.6	1.3	1.2	1.0	0.8	0.6
OIL2	1.6	1.3	1.1	0.9	0.7	0.5
OIL3	1.6	1.3	0.9	0.7	0.6	0.4
OIL4	1.6	1.3	1.0	0.8	0.6	0.4
OIL5	1.6	1.3	0.9	0.8	0.6	0.4
OIL6	1.6	1.3	0.9	0.8	0.6	0.4
NORTH						
BASE	15.8	14.4	13.0	10.9	7.7	4.3
OIL1	15.8	15.2	14.0	11.6	8.0	4.3
OIL2	15.8	15.2	13.2	10.8	7.3	3.9
OIL3	15.8	15.2	11.1	8.8	5.6	2.8
OIL4	15.8	15.2	11.1	8.8	5.6	2.9
OIL5	15.8	15.2	11.6	9.2	5.9	2.9
OIL6	15.8	15.0	10.9	8.6	5.6	2.8
NON-NORTH						
BASE	1.7	1.3	1.0	0.7	0.4	0.2
OIL1	1.7	1.4	1.1	0.7	0.4	0.2
OIL2	1.7	1.4	0.9	0.6	0.3	0.2
OIL3	1.7	1.4	0.6	0.4	0.2	0.1
OIL4	1.7	1.4	0.8	0.5	0.3	0.2
OIL5	1.7	1.4	0.7	0.4	0.2	0.1
OIL6	1.7	1.4	0.6	0.4	0.2	0.1

Source: Authors' analysis based on the model described in the text