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The Challenges of Macroeconomic Management of Natural Resource Revenues in Developing Countries: The Case of Uganda

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS: I
ABSTRACT 1
1. INTRODUCTION 2
2. MACROECONOMIC PERFORMANCE AND ENERGY SECTOR INDICATORS 3
3. LITERATURE REVIEW 4
4.1. Household Sector 8
4.2. Representative firms 10
4.3. Natural resource sector 10
4.4. Government 10
4.5. Market clearing and current account 11
4.6. Competitive equilibrium 11
5. FISCAL REGIME, UPSTREAM ECONOMIC MODEL, AND PROJECTION OF OIL REVENUES IN UGANDA 11
6. CALIBRATION 12
7. POLICY SIMULATIONS 13
8. CONCLUSIONS 17
REFERENCES 18
EPRC RESEARCH SERIES 27

ABSTRACT

Recent natural resource discoveries in East Africa provide an enormous opportunity for development. We focus on oil discoveries in Uganda and their expected impact on government revenues. We analyze alternative spending policies of natural resource revenues using a calibrated dynamic, stochastic, general equilibrium model (DSGE). We use detailed publicly-available information on the upstream oil sector and the fiscal regime to derive realistic cost and government revenue profiles across a range of oil price scenarios. This enables us to project annual production, fixed and variable costs, and government revenues for given global oil price paths. We compare the potential effects of income transfers versus public investment spending, as well as front-loaded versus gradual public investment policies. We also assess the impacts of alternative assumptions on the efficiency of public investment due to constraints on absorptive capacity. In terms of economic welfare, income transfers dominate public investments (whether gradual or front-loaded) given the typically low discount factors for households in low-income developing countries. Similarly, front-loaded investment policies dominate gradual investment policies given the low discount factors. However, our simulations show that as individuals care more about the future (i.e. have a lower discount rate), the welfare order of policies change, as the productivity effect of public investment produces a higher increase in consumption and welfare even though this increase is lagged in time.

JEL classification: *Keywords*: Natural resource revenues, Dutch disease, resource curse.

1. INTRODUCTION

The recent discovery of significant reserves of oil and gas in East Africa provide an enormous opportunity for economic development in the region. Exploration in the Albertine Graben region has confirmed the existence of 2.5 billion barrels of commercial oil reserves. This presents Uganda with the chance to transform the economy. The government expects to receive significant revenues from the oil sector which can be used to implement policies for enhancing economic growth opportunities, promoting sustainable economic development, alleviating poverty and improving standards of living.

However, this opportunity is not without risks and challenges often referred to as the resource curse. Dependence on hydrocarbon natural resources for economic growth has been frequently linked to low-income countries experiencing poor macroeconomic performance and growing inequality. The topic has long been an important research area. Papers by Gelb (1988), Sachs and Warner (1999 and 2001) are good examples; van der Ploeg (2011) presents a useful survey of the research. Macroeconomic risks present themselves in two main ways. First, there is a potential deterioration of non-resource tradeable (exporting and import competing) sectors (the Dutch Disease). The possible adverse consequences of uncertainty and volatility in global oil prices on government revenues constitute the second source of macroeconomic risk.[1] These can complicate fiscal planning, often resulting in inefficient pro-cyclical "stop-go" government expenditures .

The objective of our research is to capture the important macroeconomic effects resulting from the expected natural resource development in Uganda. Our modeling approach is similar to Berg et. al. (2013); however, their focus was on public investment effects for Angola and the CEMAC countries. We use a Dynamic Stochastic General Equilibrium (DSGE) model, calibrated for the Ugandan economy, to simulate and evaluate the result of alternative expenditure policies under different price paths. A unique contribution in our work is the detailed treatment of expected resource revenues based on detailed upstream cost and fiscal revenue estimates.

Governments in many resource-rich countries face two important and related challenges or decisions with regard to the resource rents: How much of the resource rents should be spent or saved? How to spend the revenues? The resources are exhaustible, the rents are affected by the fiscal regime, and the rents vary with global energy prices and the rate of resource extraction. Resource-rich developing countries must make decisions targeting their main goal to generate sustained growth and alleviate poverty.

Meeting these challenges requires understanding the resource endowment of the country as well as technical and economic variables. For example, the types of reserves (gas vs oil), the quality of the crude oil or natural gas, and the technical challenges to production (depth level, onshore vs offshore) affect the costs associated with exploitation of the resource, and therefore the expected rates of return for the oil company and the government's fiscal take. The level of tax rates and the types of fiscal instruments (royalties, cost recovery limits, corporate taxes, depreciation allowances, etc.) affect the ultimate exploitation of the natural resource and the time profile of the extraction (Smith, 2014). These can impact not only the extraction profile of the resource, but also the distribution of resource rents among the stakeholders.

We analyze and compare the macro-economic and welfare effects of alternative government expenditure policies given the resource potential and revenues under the current fiscal regime in Uganda. Three broad policy options under different oil price scenarios are considered:

1. Income transfers to households[2].
2. Front loaded public investment in infrastructure.
3. Gradual public investment in infrastructure.

In our analysis, we compare the effects from the traditional prescription of saving resource rents in a

1 For instance, this was noted in a recent speech by the Governor of the Bank of Uganda (Tumusiime-Mutebile, 2015).

2 Our model is based on a single representative household; the direct increase on disposable income in the model associated with the income transfer policy can be interpreted as an increase of the average income and a reduction of poverty in the actual economy.

sovereign wealth fund with the other spending options of front-loading public investment to increase productivity and cash transfers to alleviate poverty. We take into account two specific characteristics of public investment in low-income developing countries. They are: (i) the lack of public infrastructure, and (ii) the existence of constraints in absorptive capacity reflecting economic, policy and institutional bottlenecks. These reduce the efficacy of implementing rapid and large increases in public investment.

There are five remaining sections to the paper. Section 2 provides an overview of Uganda's macroeconomic performance and energy sector indicators. The next section reviews the relevant literature. Section 4 describes the model used for the analysis. We explain the fiscal regime, upstream model, and projections of oil revenues in Section 5. This is followed by a discussion of the data and calibration of parameters in Section 6. Section 7 contains the policy simulation analyzing the impact of alternative spending policies regarding government revenues collected from natural resource exploitation on economic welfare. Conclusions are presented in the final section.

2. MACROECONOMIC PERFORMANCE AND ENERGY SECTOR INDICATORS

Table 1 provides the basic macroeconomic indicators since 2010. Nominal GDP in 2014 was approximately Ugandan Shillings (Ug. Shs) 64 trillion or $23 billion. In real terms using 2009/2010 prices, Uganda's GDP was Ug. Shs 51 Trillion. Income per capita in nominal US dollars was $660 in 2014[3]. Inflation spiked to 27% in 2011. However, the Bank of Uganda (BOU) has brought inflation down quickly to just over 5% by the following year. In 2014, the inflation rate was 4.3%.

Uganda's National Development Plan (NDP) and Vision 2040 have targeted an average annual growth rate of 7% (MFPED, 2014). Real economic growth was about 5.9% on an annualized basis in the 1990s and increased to 6.9% in the 2000s. On a per capita basis income growth averaged 3% in the 1990s and 3.8% in the 2000s. Uganda's growth performance was relatively weak over 2012 – 13. In 2012 per capita income growth actually fell. In 2014, economic growth recovered to 6.5%, and per capita GDP grew by 3.5%. The weak performance was due to challenging global financial conditions, delays in infrastructural investment projects and vulnerability to external risk perceptions. However, recent improvements in growth and per capita incomes are associated with favourable weather conditions for agricultural production, lower oil prices (and thus a reduced import bill) and prudent macroeconomic policies.

Given government objectives along with the potential for oil revenues receipts in the near future, infrastructure investments have picked up. According to the 2015/16 budget (MFPED, 2015), the overall fiscal balance (including grants) is projected to amount to a deficit of Shs 4,220 billion, or the equivalent of 5.6% of GDP in FY2014/15 and is expected to increase to Shs 5,700 billion, or 6.8% of GDP in FY2015/16. The deficit is expected to decline over the medium term, reflecting the completion of the major infrastructure projects and in line with the EAC monetary union convergence plan. The deficit will be financed through external and domestic sources. Public debt was just over 30.0 percent of GDP in 2014 (see Table 1).While the amount of debt is of concern, it is within the range estimated by the public debt management framework of 2013 and East Africa's Monetary Union convergence criteria (50 percent debt-to-GDP ratio) (MFPED, 2015). However, the increase in debt is expected to increase inflation and depreciate the Uganda shilling considerably. The US dollar was trading at Ug. Shs 3100 in June 2015, a 20 percent depreciation since November 2014.

Table 2 provides a summary of energy indicators for Uganda.[4] It is broken out into three main sections: primary energy, electricity and refined oil products. According to EIA data, estimated primary energy consumption grew from 0.48 million tons of oil equivalent (MTOE) in 1990 to 1.49 MTOE in 2012, equivalent to an annual compound growth rate of 5.2%. In per capita terms, the growth rate for primary energy consumption was 1.6% in the 1990s and 2.2% since 2000.

3 Recent changes in the GDP benchmark year for prices and differences in reporting between the Bank of Uganda and Ugandan Bureau of Statistics suggest that the data be considered preliminary.

4 The source for the data is the US Energy Information website at www.eia.gov

Estimated energy consumption per capita in 2011 was 0.047 tons of oil equivalent.

The importance of electricity and refined petroleum products has grown and will continue to grow in importance. In 1990, they constituted about 30% of total primary energy consumption. Today over 50% of primary energy consumption is accounted for by electricity and refined petroleum products. Electricity generation is dominated by hydropower, but since 2005 the growth in demand and problems with river flows has curtailed its share of the power generation sector. Fossil fuel power generation has grown from zero to 17% of total power generation. Total generation is about 3 billion kilowatt hours (KwH); 0.5 billion KwH is produced by fossil fuels. Distillate fuel consumption increased rapidly from 4.5 thousand barrels per day (tbd) in 2005 to 12 tbd in 2008; almost the entire increase was accounted for by power plants. Electricity generation and consumption are expected to grow at 6%-7% annually for the foreseeable future.

Currently, Uganda imports all its refined petroleum product requirements. The annualized growth rate of refined product consumption was 3% in the 1990s. This has more than doubled to over 7% since 2000. Current total consumption is about 22 tbd and the annual growth rate of 7% is likely to continue. One of the biggest contributors is motor gasoline which accounts for 6.5 tbd. The Ugandan government recently announced plans to build a joint venture refinery to utilize some of the crude production when it commences. The economic viability of building a refinery will be a function of a number of factors which will determine refining margins and the return to investments: marketing margins on domestic sales and potential sales to neighboring countries which currently import refined products via ports in the Indian Ocean; refining margins elsewhere in the region; costs of transporting crude oil to the nearest sea-port and the cost of importing refined products.

3. LITERATURE REVIEW

This literature review covers four main areas in the management of natural resource revenues. They are the Dutch Disease, the resource curse, the permanent income hypothesis, and absorptive capacity.

Dutch Disease

The term Dutch Disease was first used to refer to the negative effects on Dutch manufacturing from natural gas discoveries and exports from the Groningen field during the 1970s. First, the increase in profitability of the oil sector (caused by resource discovery and by favorable price shifts for the resource owner) bids up prices of factors of production, and draws away such factors from other sectors in the economy. Since the prices of tradeables are exogenously fixed by world prices, the movement of factors of production into the oil sector contracts the non-oil tradeables sector. Second, to the extent that some of the oil revenue windfalls are spent on non-tradeables (that is, non-tradeables in the aggregate are a normal good), the price of non-tradeables determined by supply and demand within the economy is bid up relative to the price of tradeables. This phenomenon – the contraction of the non-oil tradeables sector and the associated exchange rate appreciation defined as the rise in the price of non-tradeables relative to tradeables as a result of the general equilibrium effects of a booming sector – has been termed as the Dutch Disease. Sachs (1996) discusses the relationship between real exchange rates and resource exporting developing countries in Latin America and South East Asia.

Governments can mitigate the impact of the Dutch Disease by delaying consumption or investment in the domestic economy, in favor of purchasing foreign financial and capital or property assets instead. This deferral from spending domestically can be achieved through oil trusts and sovereign wealth funds (SWFs) managing a portfolio of foreign investments. Their mandate or objective is to achieve the highest risk-adjusted returns for the nation's natural resource rents. This avoids excessive current domestic investment or consumption expenditures, which lead to appreciation of the exchange rate and collateral effects of the Dutch Disease. The optimal tradeoff between choosing to invest in the domestic economy or to save in an SWF depend not only on the relative risk-adjusted rates of return to capital invested overseas and in the domestic economy. It also depends crucially in the constraints arising from the domestic economy's absorptive capacity. We will address absorptive capacity issues more fully later below.

The spending effect on the domestic economy from the surge of natural resource rents that accompany resource booms (either due to new resource extraction or to resource price increases) is accentuated when the rents are used to expand the public sector. Government consumption expenditures are skewed towards non-tradeables like the construction and services sectors. Governments can use the windfall gains to reduce the deficit on the external trade account while limiting the rate of domestic investment of such windfall gains to within the country's (growing) absorptive capacity. This helps mitigate the appreciation of the exchange rate associated with the Dutch Disease. Warr (1984) for instance suggests that Indonesia's unusually good economic performance since the mid-1970s can be explained as a result of the low proportion of windfall revenues consumed in favor of investments in the tradeables good sectors such as agriculture, and the use of foreign exchange receipts to reduce the deficit on the balance of payments account (Doshi, 2015).

Although the Dutch Disease is generally seen as a "natural" reallocation phenomenon – the normal outcome of a market economy adjusting to the effects of a natural resource-based windfall – it is a major problem in low-income developing countries for two reasons. First, agriculture is the largest sector in terms of employment for most of the least developed economies such as Uganda. Any contraction in that sector as a result of the resource "boom" will have large adverse impacts on rural incomes and the labor market. Second, when the resource boom is over, it will be costly for the economy to recover activity in traditional export sectors, in agriculture and manufacturing (to the extent the latter existed prior to the resource boom). The decline in the tradeables sector during the resource boom period may lead to a costly de-accumulation of physical and human capital – at the expense of the long-term development of the economy (van Wijnbergen, 1984).

It is in this context that governments pursue local content and industrial development policies and programs. Local content regulations have been widely advocated in the resource rich developing countries of sub-Saharan Africa as a means of integrating the extractive sector activity with the domestic economy. These policies are controversial in that they raise the cost (at least initially) of developing the resource and are in and of themselves anti-competitive over the medium to long-run.

Most developing economies undergoing resource booms typically channel revenue windfalls into government coffers via taxes and royalties. Natural resource extraction industries such as oil and gas are typically capital intensive, based on foreign direct investments engaged in "enclave" activity with limited linkages to the domestic economy. Inputs of skilled labor, intermediate goods, and capital have to be imported because of the low levels of domestic capacity and local wages constitute a small fraction of the value added in the sector. Thus the effects of the Dutch Disease are strongly influenced by how governments as the major domestic recipients of resource rents spend their resource rent windfalls. Corden (1984) summarizes the Dutch Disease challenge in economics as follows:

"…the government policy reaction issues and, in particular, the way governments spend their extra revenues resulting from the booms has been somewhat underplayed, or at least not sufficiently highlighted in the literature and yet this has been the major concern in many developing countries."

Resource Curse

Gelb (1988) is credited with coining the term "resource curse" to describe why macroeconomic performance and development outcomes of resource-rich developing countries (RDCs) were inferior to that of other developing countries. RDCs where the resource curse prevailed include Iran, Nigeria, and Venezuela. The hypothesis is counterintuitive: countries with greater natural resource endowments should be able to perform better than resource-scarce countries other things being equal. Auty (1993) and Auty and Gelb (2001) review many of the political economy issues related to the "resource curse."

Sachs and Warner (1997a and 1997b) showed that economies with a high ratio of natural resource exports to GDP in 1971 (the base year) tended to have low growth rates during the subsequent period 1971-89. The observation held even after controlling for variables found to be important for economic growth, such as initial per capita income, trade policy, government efficiency, investment rates, and other variables. One conclusion is that resource abundant countries are high-price economies and this reduces their potential for export led growth.

The public choice argument about the resource curse phenomenon is that resource rents provide an opportunity for governments to derive political benefits of an expanded public sector without having to bear the political costs of increasing tax rates. Acemoglu and Verdier (2000) argue that the existence of these natural resource rents is a motivating source for corruption and misappropriation of public resources. Bebbington et. al. (2008), Brunnschweiler and Bulte (2008), Ross (1999), Collier (2003), Collier and Hoefler (2005) discuss how natural resource windfalls create weak institutions that undermine sustainable and inclusive development, leading to a concentration of benefits to a narrow beneficiary group.

Resource booms can lead to the entrenchment of autocratic regimes, the onset and persistence of civil conflict and the undermining of legal and constitutional norms as shown in Collier (2008), Le Billon (2001), and Ross (1999 and 2006). Predatory governmental institutions, factional fights and rent-seeking behavior by entrenched elites are well covered in the literature on the resource curse in resource-abundant, developing country contexts (Auty, 2001). Ebrahimzadeh (2012) shows that even the developed economies, with well-established governance and legal institutions can be afflicted by the resource curse as well. In Holland and Australia, for instance, government policy responses to large windfall gains from resource rents tended to support unsustainable social welfare transfers which then could not be easily dismantled following the resource boom period. Auty (1994) reviews the difficulties that arise in the reform of industrial policy as economies transition to becoming developed countries. Doraisami (2015) finds that in the wake of the 2008 global financial crisis, Malaysia began to exhibit "resource curse" characteristics where previously there were none. Thus the real factors at play in the "resource curse" phenomenon are weak institutions, poor governance, and rent seeking.

The Permanent Income Hypothesis

Hydrocarbon and other non-renewable reserves are essentially finite and eventually the resource revenues to the government will cease as the resource constraints are increasingly binding.[5] Resource booms usually end, either because the country runs out of easily accessible extractive resources and costs of production increase or commodity prices enter into a prolonged slump. Given some level of substitutability between a depleting natural asset and capital goods in any economy's production possibility frontier, an optimal policy would convert the depleting resource into productive human and capital assets over time (Collier, 2010) and (Kaiser and Vinuela, 2012).

The guiding fiscal policy framework for instituting fiscal benchmarks in many resource-rich countries has typically relied on the 'permanent income hypothesis' (PIH) (ODI, 2013). Fiscal planning takes place within the intertemporal budget constraint from expected resource revenues in addition to other revenues from the non-resource sectors. The PIH has been used to prescribe the saving of resource wealth in external financial and capital assets to avoid macroeconomic instability from spending volatile natural resource revenues in a "stop-go" pattern. The PIH requires that, for a country with only resource revenues, the intertemporal budget constraint is satisfied when the yearly spending (i.e., the non-resource primary deficit) is limited to the perpetuity that can be supported by the present value of all resource wealth (Baunsgaard et al., 2012). The constraint determines the highest level of smoothed spending over time which maximizes social welfare. Sharma and Strauss (2013) discuss the state of the debate and implications for fiscal policy and practice in resource rich countries.

PIH proponents suggest that a substantial portion of the resource wealth should be saved externally, typically in a SWF with a diversified portfolio (Davis et al.

5 For some countries with low populations and vast resources such as Qatar for example, the problem of finitude of resources is highly attenuated.

(2001), Barnett and Ossowski (2003), and Bems and de Carvalho Filho (2011)). While this policy alleviates Dutch Disease effects and avoids macro-economic instability from spending volatile natural resource revenues in a "stop-go" pattern, it fails to fully address concerns about the current poor living conditions and investment needs in capital-scarce low-income economies.

Since the mid-2000s, calls to re-evaluate PIH-inspired conventional advice and to promote earlier investment spending of resource windfalls in developing countries have emerged (UNCTAD Secretariat (2011), Collier et al. (2009), Baunsgaard et al. (2012), International Monetary Fund (2012)). The PIH has been criticized for setting spending constraints which are too tight for low-income economies. For instance, Ghura and Patillo et. al. (2012a and 2012b) argue that PIH-based consumption, spending and investment paths are not optimal for these countries. Productive government spending can dominate external saving as an optimal strategy to manage resource revenue in credit-constrained, capital-scarce economies. Examples of this approach include Takizawa et al. (2004), Venables (2010), van der Ploeg (2011), van der Ploeg and Venables (2011), and Araujo et al. (2013). When countries face high borrowing costs and debt service requirements, the optimal use of the resource revenue may well be to pay down external debt as discussed in Daban and Helis (2010) and van der Ploeg and Venables (2011).

Two alternatives to the traditional PIH approach have been proposed. The first is a 'modified PIH' which allows for an initial scaling up of spending. Berg et.al (2013) develop a model for "sustainable investing" which combines public investments with a sovereign wealth fund. This can meet the immediate demands in poor countries for both for consumption spending and public investment. Fiscal policy remains anchored to the long-term sustainable use of resource revenue. Spending can be front-loaded and financed through a drawdown from resource revenues. However, the intertemporal budget constraint forces spending to be lower in further out years. This has been likened to a "Big Push" development strategy to get the country out of poverty (Rosenstein-Rodan, 1943).

The second alternative is referred to as the fiscal sustainability framework (FSF). This alternative takes into account the intertemporal budget constraint, but stabilizes net resource wealth over a longer term than that proposed by the PIH. The FSF allows for an actual drawdown of government wealth accumulated from the natural resources. The rationale for this drawdown is to stabilize public spending at a higher level because domestic public investment (e.g., in infrastructure and human capital) enhances productivity and growth, yielding fiscal returns in the form of larger non-resource revenues. This can be referred to as an "investing to invest" policy. Proponents of the FSF argue that some front-loading of consumption spending benefits the current poor. This is welfare enhancing as their marginal utility of consumption is assumed to be higher than that of future potentially richer generations.

Absorptive Capacity

Public investment can be subject to constraints in absorptive capacity, reflecting a minimum threshold level of human capital, institution coherence, developed financial markets, trade openness, and technological and institutional capacities that determine the efficiency of public investments (Brinceno-Garamenia, Dominguez and Torres, ((2001). For instance, it requires an educated labor force to spread the benefits of new technologies across all industries (Farkas, 2012). Constraints on human and institutional capacities can reduce the effectiveness of sudden and large increases in public investment. A more gradual approach can lead to greater absorption and efficiency of spending. Muhakanizi (2011) discusses the sources and implications for budget policy in Uganda. An optimal policy, therefore would scale up public investments only in line with the growing "absorptive capacity frontier" that an economy can achieve.

One key metric in the measure of absorptive capacity is the impact of each dollar of public (and private) investment on increases in the capital stock. Not all investment -- defined as gross fixed capital formation expenditure -- contributes to capital accumulation. Two factors limit the growth in capital stock and efficiency of investment. First, public infrastructure needs can be very large and lumpy. Second, if absorptive capacity is limited, then (high) investment rates lead to large cost overruns. These can be due to supply bottlenecks, coordination issues in the implementation phase of the project, errors in measuring, reporting and verification of public investment projects and so on.

When absorptive capacity is constrained, the productivity of capital investment is reduced in the public and private sectors. There is inefficient use of investment expenditures leading to lower capital accumulation, knowledge accumulation and technology adoption per dollar spent. One measure of efficiency suggested by Pritchett (2000) is the ratio of change in public capital to investment expenditure. Hurlin and Arestoff (2010) estimate that this ratio is frequently below one-half for Sub-Saharan Africa and Latin America. Such poor investment efficiency ratios constrains productivity, the ability to compete in international markets, and ultimately economic growth prospects.

Investment costs rise in an environment of rapid scaling up and absorptive capacity constraints (van der Ploeg, 2012). The IMF estimated that the average cost overrun was 74% of the initial investment in sub-Saharan countries (IMF, 2012). Typically, seventy percent of public investment goes to capital expenditures and the rest goes to operations and maintenance. The concept of efficiency for public investment for modeling purposes would translate this value into a 70% efficiency parameter. This compares with a benchmark value from the Buffie et al. (2012) study of 60% for Sub-Saharan Africa.

While it is generally believed that large-scale public investment programs are important to speed up economic development, the many examples of wasteful white-elephant projects in many developing countries enjoying natural resource revenue windfalls exhibit the risks of breaching the limits of absorptive capacity. Heller (1974) and Rioja (2013) emphasize the need for on-going expenditures to cover recurrent costs for operation and maintenance. This reduces the rate of capital depreciation and makes public investment projects remain productive in the medium to long term. The appropriate example here is the building and maintenance of all-weather roads.

4. THE MODEL

Our model attempts to capture important macroeconomic effects resulting from a natural resource boom in a small open economy. We incorporate natural resource production costs and fiscal revenue estimates under different global oil price paths.[6] The model is used to analyze the impacts of alternative policies in utilizing windfall revenues on major economic variables like income, consumption, investment, real exchange rate, and government revenues and expenditures. Economic growth impacts and reallocations of resources within the economic sectors are also examined.

The economy is represented by a dynamic stochastic general equilibrium model (DSGE) of a resource-rich small open economy with three different goods: a tradable good subject to international competition, a non-tradable good and the natural resource. Our DSGE model attempts to capture important macroeconomic effects resulting from a natural resource boom in a small open economy.

The model consists of an infinitely lived representative household and two representative firms producing a tradable and a non-tradable good respectively. Production and prices of natural resources are assumed to be exogenous and stochastic. We consider a government that collects revenues from conventional taxation and from the natural resources sector in the form of taxes, royalties, and production sharing contracts.

4.1. Household Sector

The preferences of households are represented by a utility function given by:,[7]

$$U(C_t) = \frac{C_t^{1-\sigma}}{1-\sigma}, \quad 1)$$

$$'C_t = C_{T_t}^{\theta} C_{N_t}^{1-\theta}, \quad (2)$$

6 The model simulations in this paper uses fixed global oil price paths of $60, $75, and $90 per barrel for the given policy scenarios. We plan to extend the model by incorporating price volatility in commodity prices in future work. It should also be noted that we incorporate natural resource production costs and fiscal revenue estimates under different global oil price paths under the assumption that all crude produced is exported. Given the Ugandan government's announced plans to build a joint venture refinery to refine a portion of the crude produced, we plan to update our results in future work when data on refinery costs and downstream marketing are available to the authors.

7 We assume that labor is inelastically supplied by households (normalized to 1), so utility depends only on consumption.

Where the aggregate consumption (C_t) is given in (2) as a Cobb-Douglas aggregation of the consumption of the tradable good (C_{T_t}) and the non-tradable good (C_{N_t}).

We normalize the price of the tradable good to 1, then P_t would be the price of aggregate consumption relative to the tradable good and P_{N_t} is the relative price of the non-tradable relative to the tradable good, that is, the real exchange rate that measures the competitiveness of the economy.

Given the prices and the Cobb-Douglas aggregation, the consumer demands of tradable and non-tradable are:

$$C_{N_t} = (1-\theta)\frac{P_t}{P_{N_t}}C_t, \tag{3}$$

$$C_{T_t} = \theta P_t c_t. \tag{4}$$

The household's problem is to maximize an intertemporal expected flow of utility subject to the budget constraint and the laws of capital accumulation:

$$\max_{C_t, D_t^H, I_{N_t}, K_{N_t}, I_{T_t}, K_{T_t}} E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma}$$

s.t.:

$$D_t^H - (1+r_t)D_{t-1}^H + (1-\tau_t^w)w_t L_t + (1-\tau_t^K)\left[R_{T_t}K_{T_{t-1}} + R_{N_t}K_{N_{t-1}}\right] - T_t = [1 + \theta\tau_t^{CT} + (1-\theta)\tau_t^{CN}]P_t C_t + P_t\left[I_{N_t} + \frac{h_N}{2}\frac{I_{N_t}^2}{K_{N_{t-1}}}\right] + P_t\left[I_{T_t} + \frac{h_T}{2}\frac{I_{T_t}^2}{K_{T_{t-1}}}\right], \tag{5}$$

$$I_{N_t} = K_{N_t} - (1-\delta_N)K_{N_{t-1}}, \tag{6}$$

$$I_{T_t} = K_{T_t} - (1-\delta_T)K_{T_{t-1}}, \tag{7}$$

where β is the discount factor[8], D_t^H is foreign private debt[9], r_t is foreign debt interest rate, w_t are wages and L_t is labor, which is normalized to 1. $I_{N_t}, K_{N_t}, I_{T_t}, K_{T_t}$ represent investment and capital stock in the non-tradable and tradeable sectors respectively, while R_{N_t}, R_{T_t} are the gross return of capital in both sectors. $\tau_t^{CT}, \tau_t^{CN}, \tau_t^w$ and τ_t^K are taxes rates on consumption of tradables, consumption of non-tradables, labor income and capital income. T_t is a lump-sum government tax if $T_t > 0$ or a transfer to householsd if $T_t < 0$. δ_N and δ_T are the depreciation rates in both sectors, while h_N and h_T are the parameters governing the capital adjustment cost in both sectors.[10]

The first order conditions that define the optimal behavior of the household are:

$$\frac{\frac{\partial U}{\partial C_t}}{[1+\theta\tau_t^{CT}+(1-\theta)\tau_t^{CN}]P_t} = \beta E_t \frac{\frac{\partial U}{\partial C_{t+1}}}{[1+\theta\tau_{t+1}^{CT}+(1-\theta)\tau_{t+1}^{CN}]P_{t+1}}(1+r_{t+1}), \tag{8}$$

$$q_{N_t} = P_t\left(1 + h_N\frac{I_{N_t}}{K_{N_{t-1}}}\right), \tag{9}$$

$$q_{T_t} = P_t\left(1 + h_T\frac{I_{T_t}}{K_{T_{t-1}}}\right), \tag{10}$$

$$q_{N_t} = E_t\frac{1}{(1+r_{t+1})}\left\{(1-\tau_{t+1}^K)R_{N_{t+1}} + P_{t+1}\frac{h_N}{2}\frac{I_{N_{t+1}}^2}{K_{N_t}^2} + q_{N_{t+1}}(1-\delta_N)\right\}, \tag{11}$$

$$q_{T_t} = E_t\frac{1}{(1+r_{t+1})}\left\{(1-\tau_{t+1}^K)R_{T_{t+1}} + P_{t+1}\frac{h_T}{2}\frac{I_{T_{t+1}}^2}{K_{T_t}^2} + q_{T_{t+1}}(1-\delta_T)\right\}, \tag{12}$$

jointly with constraints (5-7), and where q_{N_t} is the ratio of Lagrange multipliers discounting constraints (9) and (8), and discounting (10) and (8) in the case of q_{T_t}.

Following Schmitt-Grohé and Uribe (2003) we induce stationarity by assuming a debt-elastic interest rate risk premium.[11] In particular we consider that the interest rate depends on the debt/GDP ratio according to:

8 The discount factor β is the inverse of the discount rate or real interest rate (net of depreciation).

9 Households have access to international capital markets in small open economy models as a way to introduce the trade balance.

10 In small open economy models the international interest rate is exogenously determined, making investment too volatile relative to the empirical evidence. This anomaly can be solved by assuming capital adjustment costs, which has become an standard assumption in the literature, see Mendoza (1991). In our model those costs hold even in steady state, reflecting developing countries capacity constraints in the private sector as a capital cost even if there are no changes in net investment.

11 Several methods have been proposed to make dynamic small open economy models stationary, including endogenous discount factor, convex portfolio adjustment costs, complete asset markets and debt elastic interest rate premium.

$$r_t = r^* + \left(e^{a\frac{D_{t-1}}{Y_t}} - 1\right) \quad (13)$$

4.2. Representative firms

We consider two different sectors: tradable and non-tradable. This structure is necessary to address the potential reallocation effects associated with the Dutch Disease. We assume competitive firms in both sectors use labor and private capital to produce goods. Public capital provides a positive externality. We assume constant returns to scale in the private inputs. The production function for non-traded and traded goods will respectively be:

$$Y_{N_t} = A_{N_t} K_{T_{t-1}}^{\gamma} L_{T_t}^{1-\gamma} K_{G_{t-1}}^{\phi} , \quad (14)$$

$$Y_{T_t} = A_{T_t} K_{T_{t-1}}^{\alpha} L_{T_t}^{1-\alpha} K_{G_{t-1}}^{\pi} , \quad (15)$$

where A_{N_t} and A_{T_t} are exogenous scale factors that could be deterministic or stochastic. Notice that labor and private capital are sector-specific inputs, while the stock of public capital is a positive externality affecting both sectors. The optimal conditions from profit maximization are:

$$w_t = (1-\gamma) P_{N_t} A_{N_t} K_{T_{t-1}}^{\gamma} L_{T_t}^{-\gamma} K_{G_{t-1}}^{\phi} , \quad (16)$$

$$R_{N_t} = \gamma P_{N_t} A_{N_t} K_{T_{t-1}}^{\gamma-1} L_{T_t}^{1-\gamma} K_{G_{t-1}}^{\phi} , \quad (17)$$

$$w_t = (1-\alpha) A_{T_t} K_{T_{t-1}}^{\alpha} L_{T_t}^{-\alpha} K_{G_{t-1}}^{\pi} , \quad (18)$$

$$R_{T_t} = \alpha A_{T_t} K_{T_{t-1}}^{\alpha-1} L_{T_t}^{1-\alpha} K_{G_{t-1}}^{\pi} . \quad (19)$$

4.3. Natural resource sector

As in most developing countries oil production is mainly conducted by international oil companies which have the requisite investment capital and technical expertise. We assume that the only channel of influence on the domestic economy would be through the revenues the government collects from the oil sector. In practice, for most developing countries undergoing resource booms, the windfalls accruing domestically primarily flow into government coffers via taxes, royalties, production sharing agreements and the like. The extractive industry sector is typically capital intensive and based on imported capital equipment and foreign direct investments. Local wages constitute a small fraction of the value added in the sector. The effects of the Dutch Disease thus are strongly influenced by how governments, as the major domestic recipients of resource rents, spend their resource windfalls.

The usual approach for modeling government oil revenues assumes stochastic processes for the international price of oil, as well as for oil production [see for instance Berg et al. (2013)]. A distinguishing feature of our approach is the detailed treatment of the fiscal regime and upstream economics in the projection of production costs and government revenues. We use public information on commercial oil reserves and on the fiscal regime to obtain projections of annual oil production and government oil revenues for a given oil price. The procedure to calculate government revenues is presented in section 5.

4.4. Government

The government collects revenues from taxes on consumption, labor and capital income, as well as from the natural resource sector (NRR_t). The government can also issue debt (D_t^G) in international markets.[12] Government spending consist of transfers to the households, public consumption (C_t^G) and public investment (I_t^G). We use the same Cobb-Douglas aggregation specified in equation (2). The government budget constraint is:

$$D_t^G + [\theta \tau_t^{CT} + (1-\theta)\tau_t^{CN}] P_t C_t + \tau_t^W w_t L_t + \tau_t^K [R_{T_t} K_{T_{t-1}} + R_{N_t} K_{N_{t-1}}] + NRR_t + T_t = (1+r_t) D_{t-1}^G + P_t I_{G_t} + P_t C_{G_t} \quad (20)$$

The government invests in public capital accumulation according to a rule that includes absorptive capacity constraints:

$$\psi(I_{G_t} - I_{G_{ss}}) + I_{G_{ss}} = K_{G_t} - (1-\mu) K_{G_{t-1}}, \quad (21)$$

where ψ represents the share of increase of public investment that is effectively transformed into productive public capital. As Pritchett (2000) points out,

12 Notice that the stock of government public debt could be negative meaning that government is saving abroad. This feature is useful to simulate sovereign wealth fund saving policies.

the difference between investment spending and effective capital accumulation is an important issue for developing countries. Sudden increases of public investment face important bottlenecks in developing countries due to the lack of administrative capacity. Dabla-Norris et al. (2012) and Gupta et al. (2014) obtain that only 40%-60% of public investment is transformed into effective public capital.

4.5. Market clearing and current account

Tradable and non-tradable markets have to clear at each period. As Walras Law holds in general equilibrium, it is only required to impose market clearing conditions in one of the markets, and the equilibrium in the other market will follow. The conditions for the market clearing in the non-tradable market are:

$$Y_{N_t} = \frac{P_t}{P_{N_t}}(1-\theta)\left[C_t + I_{T_t} + \frac{h_T}{2}\frac{I_{T_t}^2}{K_{T_{t-1}}} + I_{N_t} + \frac{h_N}{2}\frac{I_{N_t}^2}{K_{N_{t-1}}} + I_{G_t} + C_{G_t}\right]. \tag{22}$$

Proposition. In equilibrium the current account equals the change in net foreign assets.

Proof. By taking the household budget constraint given in (5) and substituting the input prices obtained in (16-19), we can use the government budget constraint given in (20) to obtain the external equilibrium equation of the Non-Natural Resources foreign trade:

$$\underbrace{D_t - D_{t-1}}_{\text{net international asset position}} = \underbrace{r_t D_{t-1} + \underbrace{P_t[C_t + I_{G_t} + C_{G_t}] - [P_{N_t}Y_{N_t} + Y_{T_t} + NRR_t]}_{\text{trade balance}}}_{\text{current account balance}} \tag{23}$$

We impose equilibrium in the labor market as follows:

$$L_{N_t} + L_{T_t} = 1.$$

4.6. Competitive equilibrium

A *competitive equilibrium* for this economy is a set of paths of allocations, prices and policies that satisfy the following conditions:

i) $\{C_t, D_t^H, I_{N_t}, K_{N_t}, I_{N_t}, K_{N_t}\}$ solve the household's problem given $\{P_t, P_{N_t}, r_t, w_t, R_{N_t}, R_{T_t}\}$ prices and policies $\{\tau_t^{CT}, \tau_t^{CN}, \tau_t^{W}, \tau_t^{K}, T_t\}$.

ii) $\{L_{N_t}, K_{N_t}\}$ solve the non-tradable firm's problem given prices $\{P_{N_t}, w_t, R_{N_t}\}$ and the policy $\{K_{G_t}\}$.

iii) $\{L_{T_t}, K_{T_t}\}$ solve the tradable firm's problem given $\{w_t, R_{T_t}\}$ prices and the policy $\{K_{G_t}\}$.

iv) The government budget constraint holds at each period.

v) All the markets clear.

5. FISCAL REGIME, UPSTREAM ECONOMIC MODEL, AND PROJECTION OF OIL REVENUES IN UGANDA

We depart from the existing literature in using a more detailed procedure to the projection of production costs and government revenues in the case of Uganda. We use public information on the oil field characteristics and reserve estimates as well as existing upstream regulations and contract information of the fiscal regime. This enables us to more realistically project annual production activity, fixed and variable operating costs, and state revenues for a given global oil price path.

There are three clusters of eighteen oil fields in the Lake Albert region known as Kingfisher, Kaiso Tonya, and Buliisa. They are operated by Tullow Oil Company, Total, and the Chinese National Offshore Oil Company (CNOOC). According to Tullow[13], the expected gross production over 26 years would be 1.3 billion barrels of oil, excluding enhanced oil recovery (EOR), with a peak of 230,000 bpd.

The Upstream Economic Model uses inputs from three main sources. The first is the assumed oil price scenario and annual production profile by cluster. The second are the associated cost estimates including development capital expenditures and annual fixed and variable operating expenses. These estimates are based on field geology characteristics, numbers of wells, injection requirements, collecting lines, and

13 Tullow presentation at Capital Markets Day 2014, June 25, London, http://www.tullowoil.com/Media/docs/default-source/3_investors/2014-tullow-capital-markets-day-pdf.pdf?sfvrsn=6

processing plants[14]. The final source is the production service contract terms or fiscal regime instruments and the level of national oil company participation. The fiscal regime instruments are summarized in Table 3. These inputs produce the pre-tax net revenue profiles and the profile for fiscal revenues or "government take".

The government of Uganda prefers to refine at least some portion of its expected crude oil production for domestic consumption and export excess refined products to neighboring countries rather than export all of its crude oil (in its unrefined form) to global markets. It has signed a contract with RT Global Resources, a Russian firm, to construct and operate an oil refinery[15]. The proposed refinery will have an initial output of 30,000 bpd growing to 60,000 bpd. There are ongoing feasibility studies for joint pipelines through Kenya[16]. Currently, our model assumes that all of the crude oil will be exported given that cost estimates for the refinery and associated revenues from domestic and regional trade are not publically available. Pipeline transportation costs are estimated to be $14/barrel from Lake Albert to ports on the Indian Ocean.

Ugandan crude oil will sell at a significant discount from the world price[17] based on its properties. It is characterized as a light sweet crude, but with high wax content. The API gravity ranges from 33-37. The pour point is relatively high at 39C in part due to the wax content which means the oil must be heated for transportation and is reflected in the high transportation cost above. Thus, if the global crude oil price is projected to be $75/barrel, Ugandan crude will only receive $55/barrel FOB at export terminal(s) on the Indian Ocean. Figure 1 shows the expected profile of the oil revenues for different oil prices ($60/bbl, $75/bbl, and $90/bbl). The revenues are expressed in 2012 real shillings by transforming nominal $ into real shilling by applying the average depreciation of the shilling and the average growth rate of the Ugandan GDP deflator.

14 We use the industry standard IHS Que$tor software.

15 http://www.bloomberg.com/news/articles/2015-02-17/russia-s-rt-global-wins-contract-to-build-oil-refinery-in-uganda The exact provisions of the contract are still being negotiated.

16 http://www.newvision.co.ug/news/663326-building-oil-pipeline-evaluation-of-firms-starts.html

17 The Brent crude oil price is usually taken as a proxy for global crude oil prices.

6. CALIBRATION

The purpose of our analysis is to conduct simulations on the alternative use of expected revenues from oil production in Uganda. Thus, we calibrate the model parameters according to the Ugandan economy as of 2012, the most recently available macroeconomic data. The values of the calibrated parameters are showed in table 4.

The risk-free interest rate r^* is taken from the IMF (2014) analysis on global real interest rates. The parameter (a) governing the risk premium is obtained from equation (13), where the debt/GDP ratio and the interest rate (r) are from the 2012 uptdate of the IMF/World Bank joint analysis of debt sustainability for Uganda.

From equation (8) in the steady state:

$$\beta = \frac{1}{1+r},$$

and given the interest rate we obtain the discount factor (β). The intertemporal elasticity of substitution (σ) comes from the estimates for African developing countries by Ostry and Reinhart (1992). [18]

The share of tradable goods (θ) in the Cobb-Douglas consumption aggregator (2) is obtained from the Ugandan data on current expenditure. We calibrate the share as the average of expenditure of tradable goods over total expenditure from the available data (2005-2009).

Data on variables as the stock of capital, labor force or labor and capital income does not exist for most developing countries and Uganda is not an exception. The lack of data is accentuated if we divide the economy into two different sectors, tradeables and non-tradeables. Sectoral production functions have to be calibrated or estimated including public capital as a separate input. We assume parameter values according to the general macroeconomic literature. We set capital share in both sectors to 1/3 the typical income share of private capital, hence assuming a value of 2/3 for labor income.

18 Those authors also estimate the discount factor, obtaining a value of 0.945, very close to the one we calibrated.

The empirical evidence on the contribution of public capital to productivity and economic growth that can be found in the literature has been inconclusive. De la Fuente (2010) exhaustively reviews the empirical literature concluding that there is evidence of a positive but small contribution of public capital in developed economies. However, developing economies may have the potential for a larger impact of public capital, as those economies are in the first stages of economic development. Given the low stock of public infrastructure, the potential impact from investments in the basic transport and communication network is likely to be large. We use a 0.135 elasticity for public capital, the estimated value obtained by Ram (1996) using data of developing countries.

The lack of data also affects the calibration of adjustment costs. We assume values for and implying that in steady state the adjustment cost is 15% of capital. We assume standard values for annual capital depreciation, 10% for private capital and 5% for infrastructure. The scale of production is settled on 1 for both sectors. Finally, we assume the absorptive capacity parameter to 1 for the benchmark case, although we will change it to analyze the impact of absorptive capacity constraints.

In addition to the structural parameters of the economy, we have to set the fiscal policy variables at the initial stage of the economy. Tax rates are calibrated according to the available data on tax revenue performance of the Ugandan Revenue Authority, spanning fiscal years from 2005/06 to 2011/12. The consumption tax rate is assumed to be homogeneous between tradable and non-tradable goods and it is calibrated as the ratio of consumption tax revenues plus taxes on imports over household final consumption expenditure. Data on revenues from income taxation does not distinguish between labor and capital income taxes. Therefore, we assume the tax rate is the same for both income sources. We calibrate the tax rate as the ratio of income tax revenues to GDP.

7. POLICY SIMULATIONS

The main purpose of the paper is to analyze the impact of different policies regarding disposition of the expected government revenues from the exploitation of recent oil discoveries in Uganda. We perform several simulation exercises to compare alternative policies. As discussed in the introduction, the traditional policy advice of international economic organizations, particularly the IMF, for natural resource-rich countries has been based on the permanent income hypothesis (PIH), advocating for the preservation of the natural resource wealth by saving the natural resource revenues externally in a (sovereign) wealth fund (SWF). That would allow a sustainable constant consumption flow equal to the present value of the resource wealth. That policy would provide fiscal sustainability as well as the preservation of the resource wealth for future generations preventing intergenerational inequality. This type of policy would also mitigate the real exchange appreciation associated with the Dutch Disease and address the issue of resource rent volatility.

However, the PIH-based policy advice has been increasingly questioned as inappropriate and too restrictive in the case of developing countries, as it ignores intrinsic characteristics such as poverty, human and physical capital scarcity and credit constraints. Thus, the IMF and other organizations (see for instance Berg et al, 2013) have started to recognize that some level of front-loaded spending (particularly public investment) would be advisable in the case of developing countries.

Along these lines, we consider two different front-loaded spending/investment policies: one in which oil revenues are spent in the form of transfers to households versus an alternative policy in which the resource revenues are invested in public infrastructure. The rationale for household transfers in developing countries is immediate poverty alleviation by increasing present consumption (and thus welfare).[19] Public investments have a longer lasting but lagged impact on poverty alleviation through the increase of productivity. However,

19 It should be noted however that financial transfers can lead to rent-seeking and issues of creating a dependency culture as the public choice literature attests to. These issues are abstracted from our discussion of policy choices in this paper.

those two policies can lead to Dutch Disease symptoms, eventually damaging the non-tradable sector, especially agricultural employment. This issue is particularly important in developing countries like Uganda, as the tradable sector includes agriculture, the main provider of employment and income for households in rural areas.

In our first simulation exercise we explore the differences between an income transfer policy, a front-loaded public investment policy and a gradual public investment policy. The gradual public investment policy consists of saving the oil revenues abroad (i.e. in a SWF) and allocating the returns plus a 10% of the fund to public investment. We simulate this three alternatives under a scenario of \$75/barrel oil price along the whole period of oil production[20]. The policy simulations are showed in Figure 1.

The distinct policy impacts can be explained by the different mechanisms through which those policies affect the economy. We can describe them through the demand side mechanism or spending effect and a supply side mechanism or productivity effect. Thus, transfers and front-loaded public investment would have the same spending effect, as in both cases government oil revenues are immediately spent, although through different channels. In the case of gradual public investment, this channel is quantitatively less important as we are spreading expenditure over a longer time span. A majority of the oil revenues are saved abroad in a SWF. In our simulation 10% of current revenues plus the return on the SWF are spent on public infrastructure. The productivity effect only applies to public investment policies, either front-loaded or gradual. The increase in efficiency of the utilization of labor and private capital in production is lower under the gradual policy but lasts longer.

Figure 2 shows how the transfers policy provides an immediate and significant rise in consumption, reaching a maximum increase around 2028, following the peak in government revenues, decreasing afterwards. Front-loaded public investment provides a slower and smaller increase of consumption, although it is sustained for longer as the productivity effect ratchets up over time. Gradual public investment further delays the consumption increase, but it is more sustained and higher over time than both, the transfers and front-loaded public investment policies. The impact of these simulations on GDP growth differ from the impact on consumption growth in that the transfers policy is dominated by investment (front loaded or gradual) across the entire simulation period. The transfers policy produces the lowest and most short-lived impact on GDP. Public investment policies increase non-oil GDP significantly as public capital investment improves productivity. The gradual policy leads to a higher and longer-lasting but delayed effect compared to the front-loaded spending policy.

All three policy scenarios cause the economy to exhibit real exchange rate appreciation. The steepest and highest upward shock on the real exchange rate is caused by the front-loaded investment policy. The exchange rate appreciation caused by transfers starts slightly later and has a lower peak. The real exchange rate appreciation caused by the front-loaded investment policy adjusts downwards after the peak faster than the real exchange rate trajectory caused by the transfers policy, reflecting the productivity increase induced by the front-loaded investment. The impact on exchange rate appreciation is most muted in the gradual investment policy scenario.

The real exchange rate reflects the reallocation process from the tradable sector to the non-tradable sector that can be seen for instance, in the response of labor or in sectoral value-added. The transfers policy causes value-added in the tradable sector to shrink more during the period of the resource extraction to 2030, while the decrease lasts for a shorter initial period under the two public investment policies. Between the two investment policies, tradeable sector value added increases faster (after the initial fall associated with the resource rent windfall) but peaks earlier and lower under the front-loaded investment. The subsequent increase in productivity under the gradual investment policy alleviates the effects of Dutch Disease. Value-added in the non-tradable sector booms most sharply under the front-loaded investment policy. Transfers cause non-tradeable sector value added to peak later and lower than the front-loaded investment policy while the gradual investment policy has a later

20 The comparison of policies is qualitatively invariant to the assumption of the international oil price.

but significantly higher peak over the longer run. The effect on both non-tradable value-added and wages is larger when oil revenues are allocated to gradual public investments because of the increase in productivity. Public investment policies, both front-loaded or gradual, offset part of the real exchange appreciation, allowing for larger and more sustainable increases in consumption. The fall in the tradable sector value-added is initially larger with the gradual policy, as the productivity increase is delayed because of the slower pace of public investment. However, the gradual approach enables a subsequent recovery which is compatible with a larger expansion of the value added in the non-tradable sector. A gradual investment policy also allows for larger and more sustainable increases in wages and the value-added in the non-tradable sector. The initial decrease of employment in the tradable sector is larger with the front-loaded investment policy as the effect of real exchange appreciation dominates the productivity effect on job creation, but the comparison is reversed soon afterwards[21].

Absorptive Capacity

As discussed in the introduction, an important issue for developing countries is the lack of institutional capacity to deal efficiently with large increases in government spending. This is particularly important in the case of public investment, as it requires appraisal, selection, and monitoring the implementation of infrastructure projects. Institutional capacity constraints decrease public investment effectiveness, reducing the effective public capital stock to below its potential. To assess the potential impact of absorptive capacity constraints, we perform a simulation exercise comparing two different scenarios of front-loaded public investment policies: one in which the country has full capacity to absorb any increase of public investment ($\psi = 1$), and the other scenario in which only 50% of the increase of public investment is effectively transformed into productive public capital ($\psi = 0.5$).

As can be seen in figure 3, absorptive capacity constraints have a considerable impact on GDP, consumption, tradable and non-tradable value added and wages, but virtually no impact on the real exchange rate and on tradable and non-tradable employment. Public investment policies produce the same spending effect which triggers the Dutch Disease symptoms of an appreciating real exchange rate and the reallocation of labor from the tradable to the non-tradable sector. Absorptive capacity does not significantly affects these variables. However, the differences in aggregate and sectoral value added, and hence in GDP and welfare, are explained by the impact of absorptive capacity constraints on productivity which measures the efficiency of public investments in building productive public capital stock.

Welfare analysis

The policy simulations we have conducted provide different dynamic responses in terms of the time paths of the relevant variables in the economy. When comparing the different policies it often occurs that no one policy prevails as optimal over the whole time span of resource extraction. See for instance the response of consumption in figure 1: the transfers policy increases consumption more in the long run, but under both the front-load and gradual public investment policies the increase in consumption can be sustained for longer periods. Thus, it is necessary to have a measure to rank the policies in terms of overall welfare. We introduce a measure to compute the intertemporal welfare gains associated with each policy.

$$\sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma}.$$

The intertemporal welfare associated to any implemented policy can be computed as the intertemporal flow of utility derived from consumption under that particular policy:

$$\sum_{t=0}^{\infty} \beta^t \frac{\left(C_{ss}(1+x)\right)^{1-\sigma}}{1-\sigma} = \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma}}{1-\sigma}.$$

We can measure the welfare gain associated to a given policy as the percentage of consumption we might compensate the consumer for not implementing the policy, that is, for not enjoying the same welfare. In terms of our model, implementing the policy leads the economy to remain at the initial steady state without any oil revenues. So the welfare gain could be com-

21 Labor in the tradable and non-tradable sector have mirror responses as we assumed inelastic aggregate labor, normalized to 1 in the model.

puted as:

Table 5 shows the welfare gains of the different policies analyzed for different oil price scenarios. Apart from the significant welfare differences between oil price scenarios for each policy, when we focus on the policy comparison the main result has to do with the comparison of transfers with both front-loaded and gradual public investment policies. This indicates that allocating oil revenues for households transfers increases welfare more than using those revenues for public investment under the assumed values of the calibrated parameters. In order to give a monetary valuation of the intended gains, we express the welfare increase in 2012 $. In order to calculate the monetary values reported in table 6, we use the data of private consumption in Uganda in 2012 (our reference year for calibration) expressed in $, along with the more recent numbers on Ugandan population (34.9 million people). Thus, the numbers reported in table 6 measure the amount of money to be used for consumption we have to compensate each individual today, to be indifferent between the current situation and the eventual situation with oil revenues used to finance the policy. For example with 90$ per barrel the transfers policy increase the welfare of an Ugandan person equivalently to give him one payment of 382.58$ for consumption. From the table we can see that the impact on individual welfare is quite modest, meaning that the government should be careful managing people's expectations.

The welfare gains reported depend, among other parameters, on the value of the discount factor . The result of household transfers policy delivering a higher welfare increase comes from the low value of the discount factor that typically emerges from the calibration process of macro-economic models of low income developing countries. Thus, the lower the discount factor the higher the valuation of present consumption relative to the future consumption. That is, as individuals become more impatient, the transfers policy is significantly more welfare improving than either of the public investment policies. The higher "impatience" (or lower discount factor) reflects poverty and the lower life expectancy of individuals in developing countries. Thus, in the context of developing countries, there is a bias in favor of the front-loaded expenditure policies. To investigate how the value of the discount factor influences the eventual welfare ranking of policies, we run the simulations where . This is the standard value for developed economies, corresponding to a 4.2% real interest or discount rate. In Table 7 we compare the welfare gain of policy alternatives when we increase the discount rate to 6.6% (in the 75$/barrel oil price scenario. The results show how the previous welfare rankings of the policy alternatives are reversed when individuals care less about the future relative to the present. Thus, transfers followed by the front-loaded investment becomes more attractive in welfare terms as the discount rate increases. The gradual investment policy fares the worst under high discount rates. Conversely, a low enough discount rate (i.e. a high enough value of) can lead the gradual public investment policy to dominate the other two policy alternatives in terms of welfare gains. When absorptive capacity constraints are included the present value of both public investment policies worsen in welfare terms relative to the policy of income transfers to households.

The existence of absorptive capacity constraints has also implications on the welfare gains of public investment policies. Table 8 reports how policy welfare gains change when absorptive capacity decreases. We simulate the scenario of 75 $/barrel comparing the situation of full absorptive capacity with the situation in which only half of the increase (above the steady state) of public investment is actually transformed into effective public capital. As it can be seen in table 8, the welfare ranking of policies is unaffected, although the welfare gains are considerably reduced for both front-load and gradual public investment policies[22]. As the welfare gains of the transfer policy are not affected by the lower absorptive capacity of public investment, the distance between the transfers policy and the public investment policies increases for the waste of resources implied by the absorptive capacity constraint. The front-loaded public investment policy still produces a higher welfare than the gradual policy, although with a lower difference.

22 Welfare gains of the transfer policy are not affected by the lower absorptive capacity of public investment.

8. CONCLUSIONS

Expected revenues from the oil sector can provide Uganda with significant rises in GDP, consumption and welfare during the next decades. By taking into account detailed industry estimates of costs and returns on upstream oil recovery in Uganda, the Uganda-calibrated DSGE model provided realistic estimates to possible trajectories for total consumption, GDP, sectoral value added, employment and wages. The trajectories of the various macro-economic variables over the simulation period depend on the policies implemented. Along with the benefits associated with the expansion of the economy, there is also the expected negative impact on tradeable sectors, namely agriculture[23] following the appreciation of the real exchange rate observed in resource-rich developing countries undergoing resource booms. The spending shock following the increase in government revenues pushes demand up, raising wages and firm profits up and therefore damaging international competitiveness through real exchange rate appreciation. The delayed spending under gradual public investment policies mitigates the Dutch Disease phenomenon, reducing the impact on real exchange rate appreciation and value added in the tradeable sector. In terms of sustainability of economic growth in developing countries undergoing resource booms, it is clear that the ability to regain competitiveness in the tradeable goods sector in the post-boom period is critical. The policy simulations rank the severity of the Dutch Disease symptoms, with the gradual investment policy dominating the two other policy alternatives, i.e. faster spending via transfers and front-loaded investments.

We ranked the policy options in terms of welfare gains, with income transfers dominating both types of public investment policies given a discount rate of 4.2%. Whether such a discount rate is appropriate for this class of DSGE models is of course a normative question. Given lower discount rates, the income transfers policy welfare-dominance over both investment policy alternatives ceases. With widespread poverty and the higher levels of morbidity and mortality, developing countries are typically assumed to have higher rates of time preference, valuing the future less, than the richer developed countries. It is important however to note that the dominance of a policy that immediately increases disposable income and therefore consumption and welfare is only as justified as the assumed high societal rate of time preference.

Our simulations show that as individuals care more about the future (i.e. have a lower discount rate), the welfare order of policies change, as the productivity effect of public investment produces a higher increase in consumption and welfare even though this increase is lagged in time. These results reflect the usual tradeoff between present and future consumption (and welfare). If individuals are very (less) impatient then policies that produce a rapid increase in consumption tend to increase welfare more (less) than policies that increase economic growth in the future. The relevance of this policy discussion in developing countries is clear, as the lack of infrastructure and human capital which require a program of public investments coexists with the problem of a significant share of the population living under the poverty line which tend to favour front-loaded spending. It is perhaps in this context that the role of "expectations management" on the part of government with respect to citizens and their ambitions for their future comes to the fore.

Developing countries have specific institutional capacity constraints and development characteristics, and face different challenges relative to their developed country counterparts. Policies successfully applied in rich countries might not be optimal for low income countries. While absorptive capacity constraints support the implementation of gradual investment policies (which alleviate such constraints over time), the higher social discount rates associated with the needs of immediate poverty alleviation suggest the attractiveness of policies which lead to income transfers. Thus, no one single policy should be advocated in terms of welfare, as the parameters measuring discount rates and absorptive capacity constraints play a crucial role in welfare comparisons. An optimal response to natural resource revenues is therefore likely to include some combination of front-loaded expenditures and more gradual public investment policies to meet the legitimate aspirations of citizens in resource-rich developing countries.

23 In the case of low income developing countries, manufacturing is often relatively small compared to agriculture.

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Table 1: Macroeconomic Indicators for Uganda

	2010	2011	2012	2013	2014
Levels					
GDP (Ug. Shs, nominal billions)	38,078	44,044	54,534	58,687	63,904
Real GDP (Ug. Shs, 2009/2010 Prices, billions)	40,988	45,011	46,259	47,887	50,986
GDP (US$, nominal billions)	16	18	20	23	23
GDP per capita (US$, nominal, estimate)	494	525	599	681	660
Fiscal Balance (% of GDP)	-5.8	-3.0	-3.3	-4.4	-5.2
Public Debt (% of GDP)	23.6	23.3	24.6	27.4	30.4
Current Account Balance (% of GDP)	-12.6	0.7	-9.8	-8.7	-10.1
Trade Balance (US$m billions)	-2.2	-2.5	-2.5	-2.1	-2.4
Growth Rates (%)					
Inflation	3.1	27.0	5.3	6.7	4.3
Real GDP	5.5	9.8	2.8	3.5	6.5
Real GDP per capita, estimate	2.4	6.7	-0.3	0.5	3.5

Source: Bank of Uganda (BOU) and Uganda Bureau of Statistics (UBOS)

Table 2: Energy Indicators

	Compound Annual Growth Rate (%)		Level
	1991-00	**2001-12**	**2012**
Primary Energy in million tons of oil equivalent			
Production	7.2	3.4	0.6
Consumption	4.6	4.5	1.5
Consumption per Capita (TOE)*	1.6	2.2	0.1
Electricity in Billion Kilowatt Hours			
Consumption	8.0	6.6	2.8
Generation	7.2	5.4	3.0
Hydroelectricity	7.2	4.0	2.4
Fossil Fuels	n.a.	n.a.	0.5
Petroleum Products in thousand barrels/day			
Motor Gasoline	4.9	5.4	6.4
Distillate Fuel	2.9	10.8	12.0
Total	3.0	7.2	22.0

Note: per capita consumption estimate is in tons of oil equivalent for 2011.

Source: U.S. Energy Information Administration - International Data Browser, accessed July 6th, 2015.

Table 3. Fiscal Regime Instruments, Values, and Assumptions

Instrument	Rate or Amount
National Oil Company or State Participating Interest	15% with E&A and development cost carried
Royalty rate	5% for first 2.5 tbd rising to 12.5% for 7.5 tbd or more
Oil cost recovery limit	60%
Profit Sharing based on average production	40% for first 5 tbd rising to 65% for 40 tbd plus
Corporate income tax rate	30%
Depreciation for tax purposes method years of useful life	6% straight line
Branch remittance taxes	15%
Surface rental for 350 km^2	\$2.5-\$7.5/ km^2 during exploration and \$500/ km^2 during production
Training fees exploration period	\$50,000
Training fees production period	\$150,000
VAT	Not applicable yet
Withholding Tax on Services	Not applicable yet
Impact of Local Currency Fluctuation on Depreciation	Not applicable yet

Source: Ministry of Energy and Mineral Development and Ministry of Finance of Uganda

Table 4.a Parameter Values used in the Model

PARAMETERS		
σ	Inverse of intertemporal elasticity of substitution	1/0.451
β	Discount factor	0.938
θ	% of traded goods on aggregate consumption	0.5633
r^*	Risk free world interest rate	0.51%
a	External debt risk premium	0.17965
h_N, h_T	Capital adjustment cost	30
α	Private capital elasticity tradable sector	1/3
γ	Private capital elasticity non-tradable sector	1/3
ϕ, π	Public capital elasticity in both sectors	0.135
δ_N, δ_T	Private capital depreciation rate	0.1
μ	Public capital depreciation rate	0.05
A_N, A_T	Scale productivity parameter both sectors	1
ψ	Absorptive capacity	1

Table 4.b Calibrated exogenous policy variables in initial steady state

EXOGENOUS POLICY VARIABLES (at the initial steady state)		
τ_t^{CT}, τ_t^{CN}	Consumption taxes on tradable and non-tradable	11.23%
τ_t^{W}	Labor income tax	3.66%
τ_t^{K}	Capital income tax	3.66%
C_G	Public consumption share of GDP	13.3%
I_G	Public investment share of GDP	5.6%
D^G	Public foreign debt over GDP	32.9%

Table 5. Policy welfare gains expressed as % of steady-state consumption.

POLICIES	OIL PRICE SCENARIOS		
	90$	75$	60$
Household transfers	4.82%	3.51%	2.22%
Front–load public investment	4.39%	3.20%	2.02%
Gradual public investment	4.06%	2.97%	1.88%

Table 6. Discounted net present value of policy welfare gains expressed in 2012 $.

POLICIES	OIL PRICE SCENARIOS		
	90$	75$	60$
Household transfers	382.58$	278.55$	176.13$
Front–load public investment	348.39$	253.87$	160.32$
Gradual public investment	322.26%	235.65$	149.19$

Table 7. Policy welfare gains (expressed as % of steady-state consumption) for different values of the discount factor in the 75$/barrel oil price scenario.

POLICIES	DISCOUNT FACTOR β	
	$\beta = 0.96$ (Discount rate = 4.2%)*	$\beta = 0.938$ (Discount rate = 6.6%)*
Household transfers	3.33%	3.51%
Front–load public investment	4.22%	3.20%
Gradual public investment	4.01%	2.97%

*Note: the discount factor is the inverse of the discount rate net of depreciation

Table 8. Policy welfare gains (expressed as % of steady-state consumption) for different values of absorptive capacity in the 75$/barrel oil price scenario.

POLICIES	ABSORPTIVE CAPACITY ψ	
	$\psi = 1$	$\psi = 0.5$
Household transfers	3.51%	3.51%
Front–load public investment	3.20%	1.55%
Gradual public investment	2.97%	1.46%

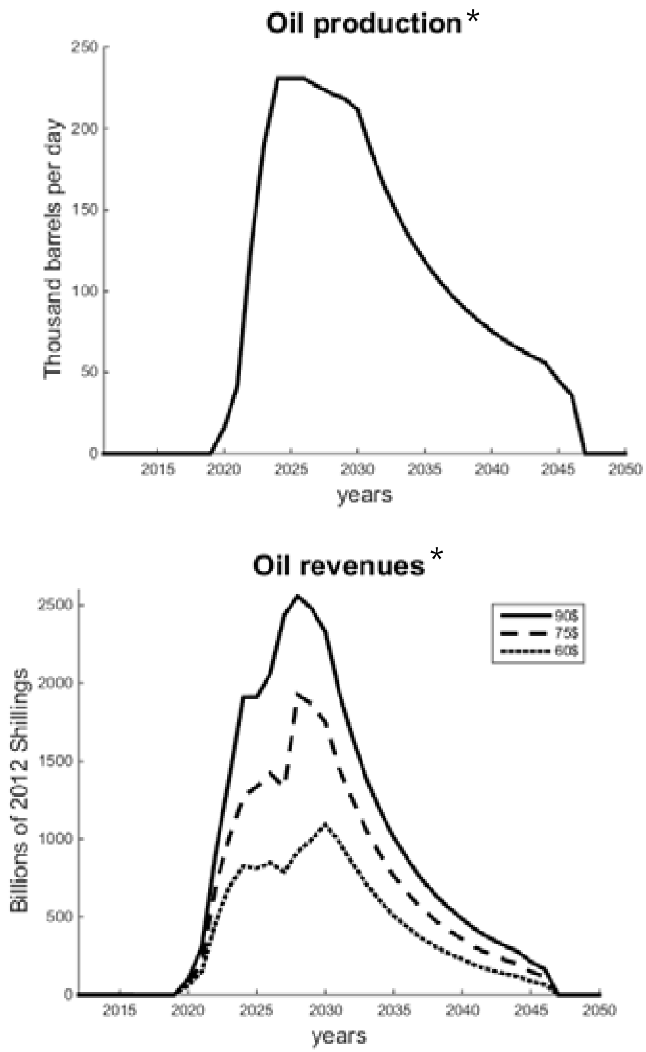

Figure 1. Expected oil production and expected government oil revenues profile.

*Note: The simulations for oil revenues are estimated on the assumption that all Ugandan crude oil production is exported. The Ugandan government has announced plans for investing in a joint-venture domestic refinery that will account for a share of the oil production; however as the data regarding the costs of the refinery and downstream marketing of products in Uganda and the East African region was not available to the authors at the time of writing, we have used the simplifying assumption that Uganda exports all its crude oil via a pipeline to the Indian Ocean coast.

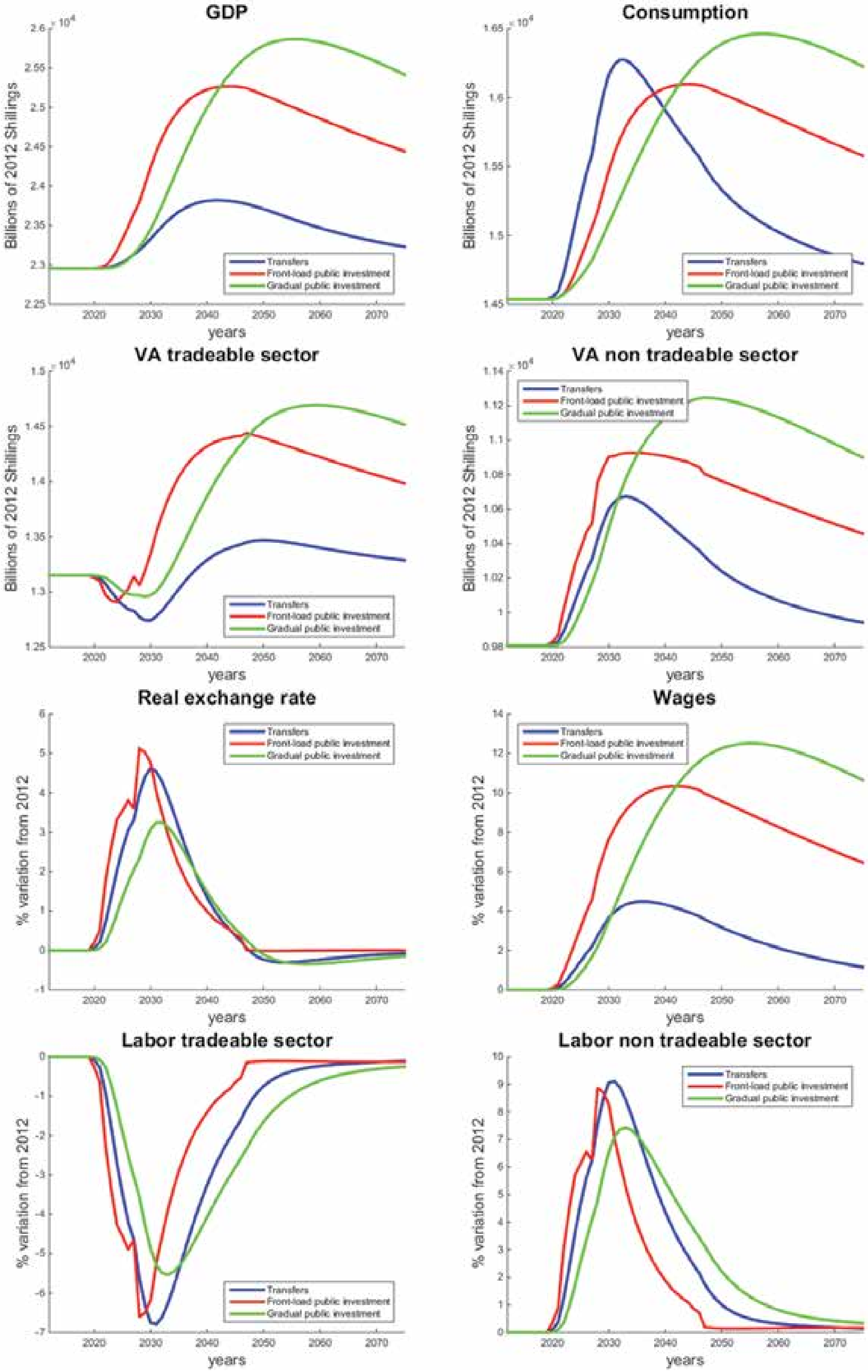

Figure 2. Policy comparison under a 75$ international oil price scenario.

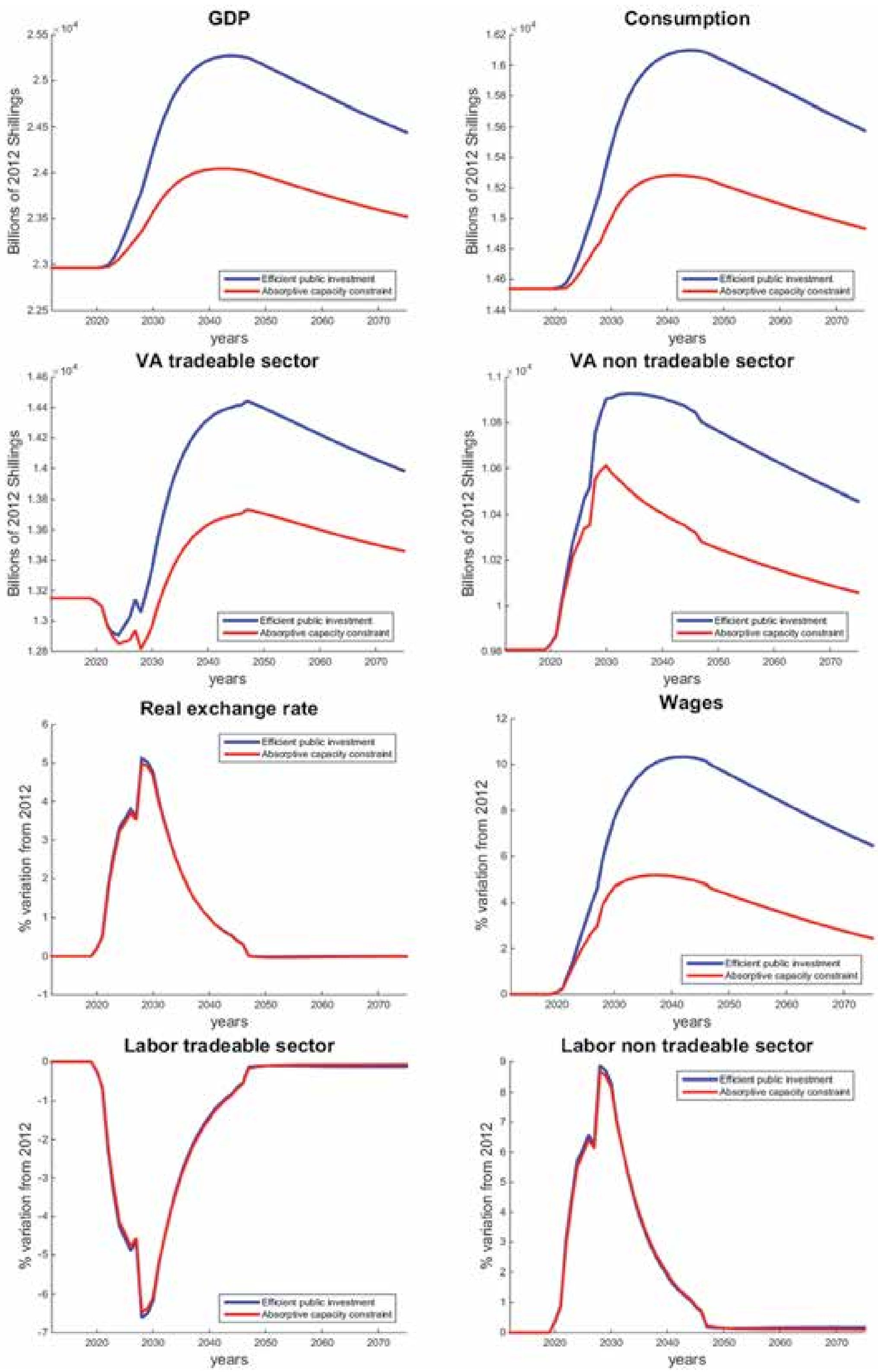

Figure 3. Absorptive capacity constraints in public investment policies under a 75$ oil price scenario.

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