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Fiscal Options for Absorbing a Windfall of Natural Resource Revenues – A CGE Model of Oil Discovery in Uganda

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Fiscal Options for Absorbing a Windfall of Natural Resource Revenues – A CGE Model of Oil Discovery in Uganda

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Abstract

The current debate about the optimal management of foreign exchange windfalls is highly relevant to low income countries such as Uganda, having recently discovered vast hydrocarbon reserves. Using a Computable General Equilibrium (CGE) model for Uganda this paper analyses three broad policy options for the use of oil revenues, increasing i) private consumption, ii) private investment, and iii) public infrastructure investment. The model allows for learning-by-doing in tradables, increasing returns to public infrastructure and the use of an Oil Fund held abroad. The fund allows government to smooth expenditure programs over the medium-term. When public infrastructure is biased towards tradables, a smooth expenditure profile yields higher economic growth than high expenditure skewed to the present. The government's discount rate plays a key role in determining the optimal use and management of oil revenues. More impatient governments will be inclined to increase current expenditure at the cost of future generations' welfare and negative distributional implications for poor households. Lower discount rates align the political incentives with respect to inter-temporal welfare and the long-run growth path of the economy.

JEL codes: E62, O11, O13, O23, Q32

Key words: Fiscal Policy, natural resources, economic development, Dutch-disease, CGE model, Uganda

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1 Introduction

Natural resource discoveries have the potential to increase growth and development. However, for many low and middle income countries resource wealth has led to poor economic performance. This phenomenon is more commonly known as the 'natural resource curse', originally coined by Auty (1993), or 'Dutch disease'[1]. Original work by Sachs and Warner (1995 revised in 1997 and 2001) formalized empirically the negative link between natural resource abundance and economic growth, showing that the majority of resource rich countries in the 1970s failed to grow significantly for the next twenty years.

The classic 'Dutch disease' process is one in which the spending of windfall revenues leads to an increase in the consumption of non-tradables, putting upward pressure on the domestic price[2]. The resulting real exchange rate appreciation decreases external competitiveness, lowering exports and depressing long-run economic growth. The link between lower tradable output and lower economic growth is key and tradables are often assumed to be conducive for growth (Rodrik, 2008). Natural resource discoveries yield, by their very nature, finite revenue streams and so understanding the impacts on the economy over the medium-term is important when developing an optimal revenue management strategy.

Much of the existing literature on developed countries advises only modest increases in current expenditure in light of a resource discovery. However, developing countries are inherently different in a number of ways which may alter this recommendation. Here we focus on two of these differences. The first is that developing countries are scarce in both private and public capital, as highlighted by van der Ploeg and Venables (2011). The second is that low-income countries are typically characterised by political instability and weak institutions.

This paper aims to analyse the macroeconomic and distributional implications of different expenditure options for a low-income country, in light of a natural resource discovery. To this end, we adapt an earlier version of the Adam and Bevan (2006) Computable General Equilibrium (CGE) model for Uganda, where vast oil reserves have recently been discovered, by incorporating an oil sector and allowing for the creation of an offshore Oil Fund (OF) which accrues excess government oil revenues in each period[3]. We allow for capital scarcity by letting production benefit from increasing returns to scale (IRS) in the presence of public infrastructure and private investment being constrained by total savings. We hypothesize that developing country governments have high political discount rates relative to rich countries. This is due to the relative wealth of future generations and the political instability in developing countries.

The policy options for the use of resource revenues examined here are to increase (a) private consumption via transfers to households, (b) private investment, and (c) public infrastructure investment. We find that allowing for positive learning-by-doing (LBD) effects in tradables

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[1] The term 'Dutch disease' was first used by the Economist in 1977 to describe the real exchange rate appreciation and decline in manufacturing in the Netherlands when natural gas was discovered in 1952.
[2] Increased demand for tradables can be met by imports at fixed world prices while increased demand for non-tradables must be satisfied by domestic production, provided the two goods are imperfect substitutes.
[3] The Oil Fund is equivalent to a Sovereign Wealth Fund (SWF) in the existing literature. By excess revenues we mean government resource revenues which are not used for expenditure policies.

results in the classic 'Dutch disease' effects over the medium-term. The oil fund allows the authorities to insulate the economy and smooth the expenditure of resource revenues, but plays a more important role when the productivity gains from public infrastructure investment are biased towards different sectors. When authorities have longer planning horizons, and so a lower discount rate, the incentive is to use the Oil Fund and smooth expenditure over the medium-term investing in public infrastructure biased towards tradables. This results in real non-oil GDP growth, strong export performance and higher incomes for the rural poor. The opposite is true for impatient governments who favour higher current expenditure. While economic growth can still be achieved over the medium-term it comes at the cost of future generations' welfare and negative distributional implications for poor households. The Oil Fund allows the political and economic incentives to be aligned.

The following section provides a brief review of the existing literature and describes the oil discovery in Uganda. Due to space constraints, it is not possible to describe the full CGE model. A simple 1-2-3 model is presented in section 3, highlighting the 'Dutch disease' effects of an oil discovery and the insulating role of the Oil Fund. Section 4 discusses some key elements of the CGE model and section 5 calibrates this to a social accounting matrix (SAM) for Uganda and presents the simulation results. Section 6 concludes the discussion.

2 Literature Review and Oil in Uganda

2.1 Literature Review

The 'resource curse' was originally formalized by Sachs and Warner (1995, 1997 and 2001) and there exists a large body of empirical work that supports the link between resource abundance and poor economic performance (Auty ,1990; Gelb ,1988; Gylfason et al., 1999; Gylfason, 2001, 2004; Mehlum et al., 2006). In fact natural resources are thought to be one of the most robust variables in empirical studies on economic growth, with negative consequences (Sala-i-Martin, 1997; Doppelhofer et al., 2000).

A natural resource discovery, like an increase in aid flows or private capital flows[4], can potentially distort the competitiveness of the tradables sector, which is typically assumed to exhibit learning-by-doing effects and so enhance productivity[5]. Romer (1986, 1990) and Lucas (1988) have shown that a faster rate of learning and knowledge spill-overs free the economy from diminishing returns and thus facilitate sustained growth. More recently, Rodrik (2008) argues that tradables suffer disproportionately from market and government failures and that an appreciated real exchange rate is bad for growth.

The key to the Sachs and Warner (2001) 'resource curse' is the link between lower production of non-resource exportables, such as manufacturing, and lower overall economic growth in the long-run. In response, a large body of literature has emerged questioning the validity of this link. Adam and Bevan (2006) for example show that the conventional 'Dutch disease' effects

[4] Proposed Increases in aid poses a risk to macroeconomic stability and growth (Rajan and Subramanian, 2005).
[5] See Neary and Van Wijnbergen (1986); Sachs and Warner (1995); Gylfason et al. (1997); and Adam and O'Connell (2004).

of aid can be overcome through targeted public infrastructure investment. Alternative explanations for the 'resource curse' have been suggested such as higher concentrations of exports (Lederman and Maloney, 2008), imperfect credit markets (Manzano and Rigobon, 2008[6]), lack of human capital (Bravo-Ortega and de Gregorio, 2007), voracity effects of boom and bust cycles (Lane and Tornell, 1996) and poor governance and institutions (Torvik and Verdier, 2006; Cabrales and Hawk, 2011; Tsui, 2011)[7].

Natural resource exploitation is a profitable business. The average annual hydrocarbon revenue as a proportion of total fiscal receipts in the top 50 countries was around 50 per cent, just over 20 per cent of total Gross Domestic Product (GDP), in the period 2000-2005 (IMF, 2007). While data on natural resource receipts is generally poor, natural resources are the dominant source of government revenue for many low or middle-income countries. African governments in particular are highly dependent on these revenue streams with oil exports in Sub-Saharan Africa around three times larger than aid receipts (van der Ploeg and Venables, 2011). Many countries continue to discover reserves of natural resources (eg. oil in Ghana and Uganda, and minerals in Afghanistan) putting pressure on the authorities to think seriously about resource management.

Historically, there have been a number of examples of both economic success and failure from resource discoveries. Norway for example benefited hugely from oil revenues in terms of growth performance and governance record. However the list of disaster cases is long[8] and there are numerous examples of high growth, resource scarce, economies[9]. One example of contrasting experiences in Sub-Saharan Africa is that of Nigeria and Botswana. Oil revenues per capita in Nigeria increased a hundred-fold between 1965 and 2000 while, over the same period, income per capita stagnated and inequality increased dramatically, leaving Nigeria among the fifteen poorest countries in the world[10]. Botswana on the other hand, with 40% of its GDP stemming from diamonds, has managed to maintain extremely high levels of education expenditure, achieve an outstanding growth record[11] and its GDP per capita is at least ten times that of Nigeria (Sarraf and Jiwanji, 2001).

The decisions taken by government during the extraction and management of natural resources can make the difference between 'curse' and 'blessing'. Collier (2010) highlights three stages to this decision process in the context of developing countries. The first is how best to capture the value of these assets, and here information asymmetries play an important role. The second is how to manage the revenue flows and is essentially a question about whether current or future generations should benefit from the revenues created. The literature has suggested three main options: the Bird-In-Hand (BIH) hypothesis in which consumption should only increase once

[6] In particular they suggest that countries used the 1970s commodity price boom as collateral and were faced with debt overhang in the 1980s when commodity prices fell, which lead to poor growth.
[7] For more recent studies see Mehlum et al. (2006); Boschini et al. (2007).
[8] The list include countries such as including Angola, The Democratic Republic of Congo, Nigeria, Saudi Arabia, Sierra Leone, Sudan, Venezuela, Zambia, etc.
[9] For a detailed discussion see Stevens (2003); Frankel (2010); and van der Ploeg (2010).
[10] In terms of income per capita. van der Ploeg (2010) estimate this to be around US$1,100 per capita in PPP terms for Nigeria.
[11] Acemoglu et al. (2003) show that Botswana has the highest per capita growth of any country in the world in the last 35 years, despite having extremely poor initial conditions for growth (extremely low education levels, bad infrastructure etc).

all the revenues have been captured, the Permanent Income Hypothesis (PIH)[12] in which consumption should increase to the annuity value of the asset, and van der Ploeg and Venables' (2011) proposition for developing countries that expenditure today should be substantially higher. The final stage of the decision-making process is what the money should be spent on. Here, Collier (2010) makes three broad suggestions, namely to encourage private investment, lower the price of capital goods, and invest in public infrastructure.

The optimal management strategy however is country specific. van der Ploeg and Venables (2011) argue that there are inherent differences between rich and poor countries. Developing countries are often capital scare, face higher interest rates as a function of domestic debt, and should therefore invest in domestic capital in order to bring forward the development path of the economy. While investing in public capital and infrastructure is often advocated, there is growing concern regarding the effectiveness of the link between public investment and economic growth. While Calderón and Servén (2004) find that the stock of public infrastructure has a positive impact on economic growth and equality, with similar findings among Sub-Saharan African countries (Calderón and Servén, 2008), the link between public investment growth is found to be less conclusive (Straub, 2008)[13].

The overarching message from the literature is that natural resource abundance is neither necessary nor sufficient for economic growth and development[14]. While the potential benefits from commodity abundance are clear, such revenue windfalls should be viewed as a double-edged sword (Frankel, 2010). Understanding the inter-temporal trade-off between economic growth and welfare is important.

2.2 Oil in Uganda

Since its independence from Britain in 1962, Uganda has failed to sustain strong economic growth and escape poverty, ranking 143rd out of 169 in the Human Development Index (2010). Table 1 gives some headline statistics for Uganda.

In 2003 Uganda's petroleum imports stood at US$ 160m per annum, the equivalent to about 40% of its export earnings and 12% of GDP (Ministry of Energy and Mineral Development, Uganda, 2003). Uganda has had a long and fragmented history of petroleum exploration beginning in 1991. Substantial oil reserves have been located in the Albertine Graben, the northernmost section of the Western arm of the East African Rift basin, which is split equally between Uganda and the Democratic Republic of Congo (DRC)[15], See figure A1 in the appendix. The first deep well drilling commenced in 2001, and was carried out by Heritage Oil and Gas Ltd. in the Semliki basin of the Albertine Graben.

Table 1: Uganda: Data and Statistics (2009)

Population, total (millions)	32.7	Life expectancy at birth, total (years)	53.4

[12] The PIH was original suggested by Barro (1979). It is advocated in the literature by authors such as Davis et al. (2002); Leigh and Olters (2006); Olters (2007); and Basdevant (2008).
[13] For an overview of the public infrastructure and growth literature see Romp and de Haan (2007).
[14] Mikesell (1997), Stevens (2003); Lederman and Maloney (2008); van der Ploeg (2010); Frankel (2010).
[15] In total the Albertine Graben is around 46,000 sq. km.

GDP (current US$) (billions)	16.0	Mortality rate, infant (per 1,000 live births)	79.4
Net ODA and Official Aid (current US$) (billions)	1.8	Literacy rate, adult (% of adults above 15)	73.0
Population below 1.25 $US (PPP) poverty line (%)	28.7	Secondary school enrolment rates	21.6*

*Source: World Development Indicators (2010). * Source: UNESCO (2010)*

In 2009 the country planned to embark on an Early Production Scheme (EPS) which consisted of producing 4,000 barrels of oil per day (BOPD), accounting for around a third of Uganda's total oil consumption. Recent estimates reveal that the recoverable reserves, in the Lake Albert region, stand at over 1 billion barrels of oil, making it the largest on-shore oil field in Sub-Saharan Africa[16]. At full scale, the region can potentially sustain production of 50,000 - 100,000 BOPD for 25 years (Ministry of Energy and Mineral Development, 2009). At an average price of US$ 100 per barrel, this is the equivalent of up to US$ 3.6 billion per year, or around 23 per cent of Uganda's GDP, almost double Uganda's aid budget.

The capital outlay required in setting up an oil sector in any country and transporting the oil to market is substantial. Uganda is no exception. Transporting the oil by road or rail may be problematic due to poor public infrastructure. One option is to build a 1,300km pipeline to the Kenyan coast and export the oil in crude form. However, due to the waxy nature of the oil the pipeline would have to be heated to allow it to flow freely, adding substantial costs to the whole process. The volume of Uganda's oil reserves seems to have overcome initial concerns about the economic viability of extraction in the Albertine Graben.

3 Simple 1-2-3 Model

In order to understand the full CGE model in the following sections, and the classic 'Dutch Disease' story of a natural resource discovery, we develop a simple two-sector model of a small open economy. This section adds a simple 'enclave' oil extraction sector to the basic 1-2-3 model of Devarajan, Lewis and Robinson (1993). In addition, a policy instrument which insulates the economy from these foreign exchange windfalls is included in the form of an Oil Fund (OF). The equation set and variables are given in table 2.

3.1 Adaptation of Basic Model

The country is assumed to have two producing sectors, a domestic non-traded good, D, and an export, E, which use Cobb-Douglass production functions and compete for labour, which is fixed. The resulting Production Possibility Frontier (PPF) is characterised by a Constant Elasticity of Substitution (CET), see Devarajan, Lewis, and Robinson (1990), and it is costly to change the allocation of production between the two markets. The production function of the composite good, X, is given by equation [1] and corresponds directly to real non-oil GDP[17]. Consumption consists of two goods, the domestic non-traded good, D, as before and imports,

[16] Previously, the largest onshore fields discovered in sub-Saharan Africa were at Rabi-Kounga in Gabon, where 900 million barrels were found in 1985, and at Kome in Chad, where 485 million barrels were found in 1977.

[17] The oil sector here generates factor payments in foreign currency. Essentially the oil sector is part of GNI but not GDP.

M, which are assumed to be imperfect substitutes[18]. Composite demand, Q, is given by equation [4].

Household income is defined by equation [10] and is made up of the value of total output plus transfers from government, while aggregate demand is given by equation [8]. Households are assumed to save a constant proportion of their total income, $\bar{s}$. Total savings in the economy is given by equation [11] and is made up of private savings, $\bar{s}Y$, government savings, S^g, and the balance of trade position, $R\bar{B}$.

Table 2: Adapted 1-2-3 Model with Government, Oil Revenues and Oil Fund

Real Flows	[8] $Q = \frac{C}{P^q} + Z + \bar{G}$	*Prices*
[1] $\boldsymbol{X = G(D^s, E, \Omega)}$	[9] $C = (1 - \bar{s})Y$	[14] $P^m = (1 + t^m)R.\pi^m$
[2] $\boldsymbol{\frac{E}{D} = g(P^e, P^d, \Omega)}$	[10] $Y = P^x.X + TRNS$	[15] $P^e = (1 + t^e)R.\pi^e$
[3] $\boldsymbol{P^x = g(P^e, P^d)}$	[11] $S = \bar{s}Y + S^g + R\bar{B}$	[16] $R = 1$
[4] $\boldsymbol{Q = F(D^d, M, \sigma)}$	*Oil and Balance of Payments*	*Equilibrium Conditions*
[5] $\boldsymbol{\frac{M}{D} = f(P^m, P^d, \sigma)}$	[12] $OF = \omega OR$	[17] $\mathrm{P^q.Z = S}$
[6] $\boldsymbol{P^q = f(P^m, P^d)}$	[13] $P^m.M - P^e.E = \bar{B} + OR(1 - \omega)$	[18] $\mathrm{S^g = T - P^d.\bar{G}}$
Nominal Flows		[19] $\mathrm{D^d = D^s}$
[7] $\boldsymbol{T = [t^m.R.\pi^m.M] + [t^e.R.\pi^e.E] + (1 - \omega)OR - TRNS}$		
Variables		
$\boldsymbol{D^s}$: Supply of Domestic Good	P^m: Price of Imports	$\bar{B}$: Balance of Trade
$\boldsymbol{D^d}$: Demand for Domestic Good	P^x: Price of Aggregate Output	R: Exchange Rate
$\boldsymbol{E}$: Exports	P^q: Price of Aggregate Output	Y: Total Income
$\boldsymbol{M}$: Imports	t^e: Export Subsidy	C Aggregate Consumption
$\boldsymbol{X}$: Aggregate Output	t^m: Import Tariff	Z: Real Investment
$\boldsymbol{Q}$: Composite Demand	π^e: World Price of Exports	$\bar{G}$: Government Demand
$\boldsymbol{\Omega}$: Export Transformation Elasticity	π^m: World Price of Imports	$TRNS$: Transfers
$\boldsymbol{\sigma}$: Import Substitution Elasticity	OF: Oil Fund (offshore)	$\bar{s}$: Propensity to Save
$\boldsymbol{P^d}$: Price of Domestic Good	OR: Oil Revenue	S: Total Savings
$\boldsymbol{P}^{\square}$: Price of Exports	ω: Share of OR kept in OF	S^g: Government Savings

3.2 Natural Resource Sector & Balance of Payments Condition

We assume that there exists an oil extraction sector which uses foreign factors or production and all output is exported. A certain proportion of the revenues can be kept 'offshore' in an Oil Fund (OF), insulating the economy from the foreign exchange windfall. This is given in equation [12] above, where ω is the share of oil revenues kept in the Oil Fund and is a key policy instrument for managing a natural resource discovery in this paper.

The oil sector generates foreign exchange revenues, OR, defined above which add to the balance-of-trade identity. This fixes the trade balance at an exogenous level, $\bar{B}$, in equation [13]. Initially we assume that the oil sector has not commenced extraction, i.e. $OR = 0$ and so $OF =$

[18] This is known as the Armington assumption, see Armington (1969).

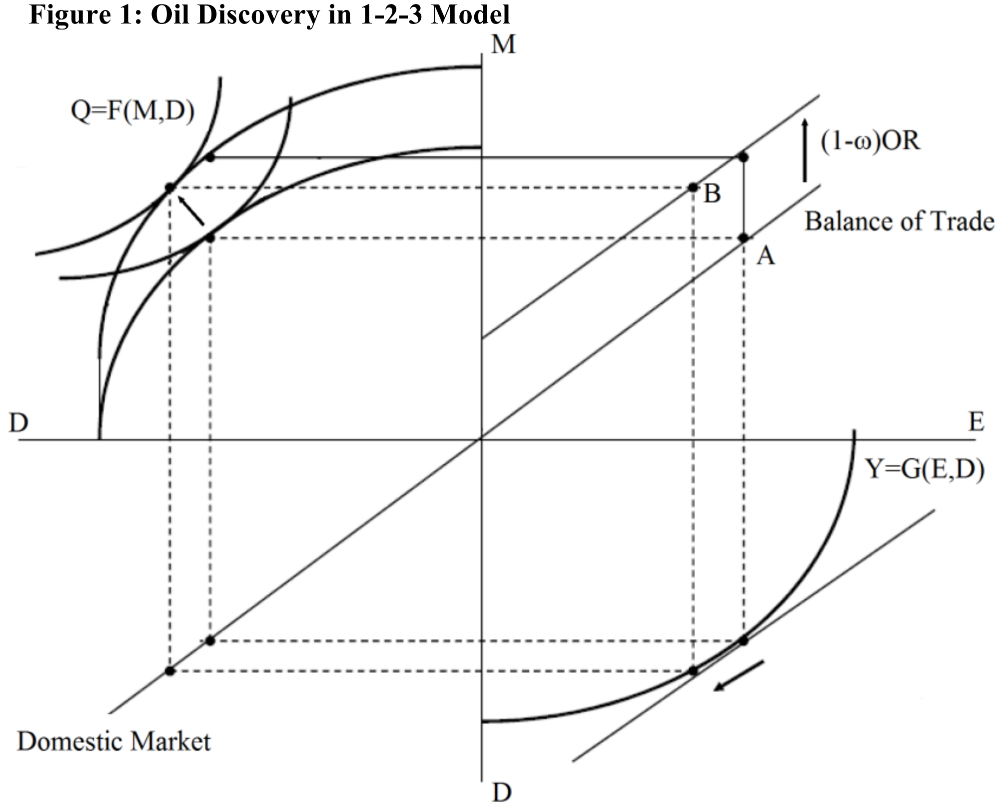
0. With no additional source of capital inflow, like aid for example, $\bar{B} = 0$ and the foreign exchange requirement must be satisfied solely by exports, that is $P^m . M = P^e . E$.

3.3 Model Analytics

The equilibrium conditions imposed on the model are given by equations [17] to [19]. Investment is savings driven and demand for domestic goods must be satisfied by domestic production. The system of 19 equations consists of 19 unknown variables. Any solution to the model depends only on relative prices and is a general equilibrium model.

Initially the economy is in equilibrium at point **A** in figure 1 below. Now, consider the effect of an oil discovery. This pushes oil revenue above its initial level of zero, $OR > 0$. The effect on the balance-of-trade position ,$\bar{B}$, depends crucially on the share of oil revenues remaining abroad, ω. If $\omega = 0$ then the total foreign exchange windfall generated by the oil discovery will be added to the balance of trade position, $\bar{B} = \mathrm{OR}$. If $0 < \omega < 1$ then the balance of trade position will lie between zero and the total oil revenue generated, $0 > \bar{B} > OR$. These two scenarios relax the balance of trade constraint $\mathrm{P^m . M = P^e . E}$, which was previously binding. Finally, the government could choose to completely insulate the economy from the resource discovery by setting $\omega = 1$, and so maintaining $\bar{B} = 0$.

Figure 1: Oil Discovery in 1-2-3 Model



Assuming that $0 \leq \omega < 1$ so $0 > \bar{B} \geq OR$, and the government transfers all revenues to households, $TRNS = OR(1 - \omega)$. The effect on the domestic price and so on the tradable and non-tradable sector depends on the elasticity of substitution, i.e. the consumption possibility frontier (PPF) defined by equation [4]. With an elasticity of substitution between zero and infinity[19], the natural resource discovery will lead to an increase in the price of D and so a real exchange rate appreciation with the economy at the new equilibrium point **B**. Production of D will increase and E will decline. This is the classic, demand side, 'Dutch disease' story.

The model presented above, while highly stylized, immediately highlights two policy instruments available to government with respect to managing the revenue windfall created by an oil discovery, ω and $TRNS$.

4 Full CGE Model of an Oil Discovery

The simple comparative static model of the previous section is unable to answer questions about the distributional consequences of an oil discovery over time and the implications of various policy options on growth. This section introduces some of the features of the dynamic simulation model used to explore the direction and magnitude of some of these effects. Due to time constraints, building a full computable general equilibrium (CGE) model was not feasible. Instead, we start with the well-defined model from Adam & Bevan (2006), add an enclave oil sector and allow the establishment of an oil fund, held abroad, into which excess oil revenues accruing to government in each period are allowed to flow.

4.1 Production & Positive Externality with Public Infrastructure

Both producers and consumers are assumed to be price takers in the model and so the terms of trade of the economy (P_M/P_E) are held constant over time, and are independent of domestic production or consumption decisions. The model consists of five sectors, food, manufactures, services, public services and oil[20], all of which are assumed to be perfectly competitive and produce a single good. The production function for sector i is determined by a Cobb-Douglass production function of the form:

$$X_{i,t} = A_{i,t} S_{i,t}^{\alpha s} L_{i,t}^{\alpha l} KP_{i,t}^{\alpha kp} KG_t^{\alpha kg} \qquad [20]$$

Where i denotes the sector and t the time period, X is domestic output, S is land, L is composite labour made up of skilled and unskilled labour[21], KP is sector specific private capital, KG is public infrastructure and is not sector specific, and A is total factor productivity (TFP). Only production of food and oil require land, where land in the oil sector is assumed to constitute the oil fields. Private sector-specific capital is fixed in each period but evolves over time, negatively through depreciation and positively through investment. The production function in [20] is characterised by constant return to scale in the private factors of production, that is $\alpha s + \alpha l +$

[19] An infinite elasticity of substitution, $\sigma = \infty$, will leave the domestic price unchanged and an increase in imports equal to the full foreign exchange windfall. Leontief preferences, $\sigma = 0$, will lead to a new consumption equilibrium on the 45° ray from the origin and the maximum real exchange rate appreciation.

[20] All oil production is exported generating a stream of foreign exchange.

[21] The labour composite input, L_i, is defined as constant elasticity of substitution (CES) aggregation of skilled and unskilled labour as $L_i = B_i\left[\theta LS_i^{\rho} + (1-\theta)LU_i^{\rho}\right]^{1/\rho}$, Where LS_i is skilled labour in sector i, LU_i is unskilled labour in sector i, and B_i is a sector-specific shift parameter.

$\alpha kp = 1$, while increasing returns to scale are possible in the presence of public infrastructure, that is $\alpha kg \geq 0$.

4.2 Household Types & Consumption

Following Adam and Bevan (2006), we assume three types of household in the model allowing the distributional impacts of the oil discovery to be examined. The first are rural households who supply only unskilled labour, produce all of the food in the economy, own all of the land and capital for food production, and do not contribute to direct taxes. The second are urban unskilled households who supply unskilled labour to all sectors other than food, pay direct tax, and own no capital or land. And finally, the third are urban skilled households who supply skilled labour to all sectors other than food, contribute to direct taxes at a higher rate than urban unskilled, and own the remainder of private capital in the economy.

All households consume food, manufactures and services, with public services being consumed only by government which remains constant. Of the four domestic sectors manufactures are tradable while food, services and public services are essentially non-tradable. Rural households produce all the food in the economy and so are net sellers of food. Both types of urban households provide labour for manufacturing, services and public services and are net sellers of services and public services.

4.3 Macro Closure – Savings and Investment

A simple macro closure rule is used in which investment is driven by savings, which in turn comes from three sources: government savings, private household savings and aid from abroad. The savings functions are defined as follows:

Household savings: $s_{hh,t} = (1 - \varphi_{hh})yd_{hh,t} + (1 - \varpi_{hh})trns_{hh}$ [21a]

Government savings: $s_{G,t} = tr_t - g_t - \sum_{hh} trns_{hh} - i_d^d.\bar{B}_t - E.i_d^f.\bar{F}_t$ [21b]

Total savings: $s_{tot,t} = \sum_{hh} s_{hh,t} - s_{G,t} + E.aid_t$ [21c]

Where hh denotes household type, yd is the disposable income by household type, φ is the propensity to consume disposable income, ϖ is the propensity to consume government transfer income, tr is total government revenue, g total government expenditure (consumption of public goods), $trns$ are transfers from government to households by household type, i_d^d and i_d^f are the domestic and foreign interest rates respectively on government debt (both taken to be exogenous), $\bar{B}$ and $\bar{F}$ are domestic and external debt stocks held by government, E is the nominal exchange rate (defined exogenously as Ush 1,750 per $US), and aid is net aid inflows in $US billions.

We assume that government investment draws from the total pool of investable resources, i.e. total savings, s_{tot}. The remaining savings are then invested by households in private capital which is allocated in relation to the rates of return in each sector. Equation set [21] is consistent with developing countries where access to capital is weak. In this setup increased government capital formation[22] directly crowds out private investment while increased savings adds to the pool of investable resources and crowds in investment. Investment moves in the direction of equalising the marginal cost and marginal product of capital but is constrained by total savings.

4.4 Learning-by-Doing

While it is widely accepted that a resource discovery is likely to lead to a real exchange rate appreciation in the short-run, the 'resource curse' depends on the effect of a resource discovery on the economy in the medium to long-run. Here we assume that positive learning-by-doing (LBD) externalities exist in the exportable sector[23]. Higher exports generate Hicks-neutral increases to total factor productivity (TFP) in the non-resource, tradable sectors. Moving resources out of these sectors and into non-tradables will have a negative impact on growth.

4.5 Oil Sector and Discovery

This paper focuses on the fiscal policy response to an oil discovery so we ignore the transition process of setting up an oil sector and scaling up production. A number of simplifying assumptions are made for Uganda. We assume that the oil sector is already established and the simulations model a simple 'turn-key' discovery. In other words, the oil discovery is met by the activation of the revenue sharing agreement, described below and in section 5.[24]

As previously mentioned the oil revenues are net factor payments in foreign currency. Capital and domestic skilled labour are used by the oil sector. Oil revenue in each period, OR_t, is defined as:

$$OR_t = pva_{oil}X_{oil} - w_sL_{oil,s} \qquad [22]$$

Where s defines skilled labour, pva is the value added price, X is production, w is the wage rate, and L is the amount of labour employed. The government leases the oil field property rights to foreign oil companies on a pre-agreed revenues sharing basis. The foreign oil companies are assumed to own all the capital in the oil sector and are therefore responsible for all capital investment (depreciation and capital deepening). Payments to the oil company, $OFROC_t$, are defined as:

$$OFROC_t = \phi . OR_t \qquad [23]$$

Where ϕ is the pre-agreed share of oil revenues accruing to the oil company. The remaining revenue accrues to government who decide what proportion of total oil revenues, ζ, to repatriate via the government budget, $OFRDR$, and what proportion to place in the oil fund as follows:

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[22] We distinguish between capital used for the production of public goods and services and public infrastructure. We allow for all current investment to add to the public capital stock with a lag of one period.

[23] The 'special' nature of the tradables sector is usually characterised by a learning-by-doing externality. See Van Wijnbergen (1984); Sachs and Warner (1995); Gylfason et al., (1997); and Adam and O'Connell (2004)

[24] We ignore any issues of bargaining power and information asymmetries between oil companies and government. While these are arguably important factors, we believe that they ultimately affect the amount of oil revenues accruing to government not the trade-offs between uses of such revenues.

$$OFRDR_t = \zeta . OR_t \qquad [24]$$

The remainder of the revenues are placed in the oil fund in each period. Note here that from section 3, equation [12], $\omega = 1 - (\phi + \zeta)$. The fund serves as an insulating mechanism for the economy and evolves according to the following equation:

$$OF_t = OF_{t-1}\left(1 + i_c^f\right) + OR_t\left(1 - (\phi + \zeta)\right) \qquad [25]$$

Where OF_t is the value of the oil fund in time t, OF_{t-1} is the value of the oil fund in the previous period, and i_c^f is the foreign interest rate. If $\phi + \zeta < 1$ then ω accrues to the oil fund in each period while if $\phi + \zeta = 1$ no revenues are accrued.

4.6 Fiscal Activities

Government chooses how to manage its share of oil sector revenues. Total government revenue, tr_t, is defined as:

$$tr_t = tariff_t + duty_t + intax_t + \sum_{hh} dirtax_{hh,t} + OFRDR_t \qquad [26]$$

Where, $tariff$ and, $duty$ represent import tariff and export duty revenues respectively, $indtax$ is the level of indirect tax revenue, $dirtax_{hh}$ is the household specific income tax revenue, and $OFRDR$ is revenues from the oil sector accruing directly to government as defined in [24]. The uses for government revenue each period, g_t are defined as follows:

$$g_t = PVA_{pub}GD_{pub} + \sum_{hh} t\square ns_{hh,t} + \sum_{hh} dint_{hh,t} + s_{G,t} \qquad [27]$$

Where PVA_{pub} is the value-added price of public goods, GD_{pub} is government demand for public goods, $dint$ is interest payments on government bonds held by households, and s_G is government savings from [21b][25].

4.7 Social Welfare & Political Discount Rate

In order to analyse the distributional impacts and welfare implications regarding the different government expenditure options we define social welfare in each period, Ω_t, as follows:

$$\Omega_t = \left[\sum (CD_{hh} - CBASE_{hh})^{\frac{1}{1-\sigma_c}}\right]^{\frac{1}{1-\sigma_c}} \qquad [28]$$

Where CD is final demand for private consumption, $CBASE$ is subsistence consumption, and σ_c is elasticity of substitution of welfare between household types. For each simulation we

[25] In addition, government invests in public capital and infrastructure equal to the deprecation rate but draws upon the total savings of the economy, defined in [21c], to do so.

compute the social welfare function in each period, Ω_t, and calculate the government's present discounted value of total social welfare over the whole simulation period as follows:

$$\mathrm{PDV}_{\Omega_t} = \sum_{t=0}^{T} \frac{\Omega_t}{(1+d)^t} \qquad [29]$$

Where d is the political discount rate. Policies which push the welfare benefits of a revenue windfall further into the future, i.e. which attempt to mitigate the classic 'Dutch disease' effects, may therefore not be optimal if the government's discount rate is sufficiently high or if the benefits of such policies would only be realised in the far away distant future. This is an important issue when considering natural resource discoveries in low-income economies where discount rates are likely to be significantly higher than in the developed world. The political discount rate for example may be very high indeed.

5 Simulation Results

The oil sector is assumed to produce around 30,000 BOPD, which, at an average price of $US 100 per barrel, results in a revenue stream of around $US 1.1 billion per year, or 24 per cent of Uganda's GDP, in line with estimates of the potential oil-revenues/GDP ratio discussed in section 2.2[26]. The revenue sharing agreement is activated upon the oil discovery. The foreign oil companies receive 75 per cent of annual revenues and the Ugandan government receives the remaining 25 per cent. The large share accruing to foreign oil companies reflects the high capital costs in setting up and running the oil sector in Uganda, as discussed in section 2.2. Government oil revenues, under the revenue sharing agreement account for around 6 per cent of Uganda's GDP.

This section describes the results of the core simulations of the full CGE model. Three broad uses of the revenue windfall are simulated as follows:

(a) The windfall is transferred completely to households and is used to increase private consumption only. That is we assume that the marginal propensity to consume this additional income is unity[27];
(b) The windfall is added to capital account and so used to increase investment in private capital in the food, manufacturing and services sectors; and
(c) Revenues are used by government to increase investment in public infrastructure, which is assumed to confer increasing returns to scale in each sector.

In each case we consider the effect of varying the proportion of oil revenues actually spent by government in each period, from 10% - 100%. The remaining oil revenues accruing to government are placed in the foreign oil fund, which is then used to continue government policy after the oil production ceases[28].

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[26] We use 30,000 BOPD rather than 100,000 BOPD as stated in section 2.2 but maintain the 23-24 percentage share of oil to GDP. The difference arises due to the difference in Uganda's GDP in 2000 compared to 2009.
[27] This comes from setting $\varpi_{hh} = 1$ in equation [21a].
[28] For a comparison with the PIH and BIH hypotheses see model output on web.

The import and export real exchange rates are sector specific and given by $e_i^M = P_i^M / P_i^D$ and $e_i^E = P_i^E / P_i^D$ respectively, where i denotes the sector. Making the small open economy assumption, with constant terms of trade, allows us to refer simply to a single real exchange rate. For simplicity, we report the volume weighted average real exchange rate across sectors, e, in the simulation output tables, which is calculated as follows:

$$e_E = e_M = \frac{\sum_{i=1}^{I}\left[P_i^E E_i \Big/ \sum_{i=1}^{5} E_i\right]}{\sum_{i=1}^{I}\left[P_i^D E_i \Big/ \sum_{i=1}^{5} X_i^D\right]} = \frac{\sum_{i=1}^{I}\left[P_i^M M_i \Big/ \sum_{i=1}^{5} M_i\right]}{\sum_{i=1}^{I}\left[P_i^D E_i \Big/ \sum_{i=1}^{5} X_i\right]} = e \qquad [30]$$

Note here that the numerator is equal to unity therefore any change in the real exchange rate is driven purely by changes in the domestic price. An increase in the price of domestic goods causes an appreciation, i.e. a fall in the real exchange rate, e.

A Social Accounting Matrix (SAM) from 2000 containing data which describes the Ugandan economy is used to calibrate the CGE model. Each simulation is run over a 20 year period, where the first period is used to for calibration. The windfall accruing to government and policy response commence in period 1 and in period 5 the oil sector ceases production completely, simulating oil reserve depletion. We use the remaining 15 periods to consider the effects of the different scenarios on the economy over the medium-term.

All results presented in this section are for a maintained set of model parameters. Sensitivity analyses were carried out and the results do not radically alter under sensible alternative parameterisation of the model. The full set of equations and variables defining the model, social accounting matrix (SAM) for Uganda, calibration data, tables and graphs of model output, and the sensitivity analysis can be found on the web at: https://sites.google.com/site/thomasmjmcgregor/home/research/cge-model-of-oil-discovery-in-uganda.

5.1 Initial Simulations & Learning-By-Doing

Table 2 presents the results of the three options for revenues, (a), (b) and (c). with and without the learning-by-doing (LBD) externality in tradables activated. In each case, the percentage change in the variable is reported relative to the initial period, i.e. the calibration period (t=0). Columns (1a) through to (1c) correspond to the three policy options without LBD externalities, while columns (2a) through to (2c) correspond to the three policy options with the LBD externalities in tradables present.[29]

Without LBD, the effects on the economy, and on real disposable incomes, of the oil discovery are negligible in the medium-term, i.e. after 20 years. However, using the oil revenues to increase private consumption has a marginally worse impact on the economy than increasing investment in public infrastructure, the most productive use of revenues. All three simulations

[29] We do not present the results when different proportions of oil revenues are used by the government, i.e. use of the oil fund. This is for two reasons. First, while the use of the oil fund results in insulating the economy from the 'Dutch disease' effects of the oil discovery, it brings little additional insight into such effects. And second, space constraints do not permit the presentation of these results. See web for full tables of simulations.

result in a strong real exchange rate appreciation and a fall in exports in the short-run. The economy bounces back in the medium-term (from t=5 onwards) with no significant change in the level of real non-oil GDP and non-oil exports. There is little evidence of the' Dutch disease' beyond the short run.

Table 2: Policy Scenarios With and Without Learning-By-Doing

	Period	1a. Private Consumption	1b. Private Investment	1c. Public Infrastructure	2a. Private Consumption	2b. Private Investment	2c. Public Infrastructure
Key Model Parameters							
Learning-By-Doing Spillovers in Ts		Off	Off	Off	On	On	On
Return to Public Infrastructure		Neutral (0.75)	Neutral (0.75)	Neutral (0.75)	Neutral (0.75)	Neutral (0.75)	Neutral (0.75)
Elasticity of Substitution (CES)		0.75	0.75	0.75	0.75	0.75	0.75
Elasticity of Transformation (CET)		0.75	0.75	0.75	0.75	0.75	0.75
Proportion of Government Revenues Used		100%	100%	100%	100%	100%	100%
Macroeconomic Variables							
Real Exchange Rate	t=1	-24.88%	-22.76%	-22.62%	-24.88%	-22.76%	-22.62%
	t=5	-0.09%	0.17%	2.08%	-0.71%	-0.41%	-0.20%
	t=15	-0.07%	0.12%	1.88%	-3.18%	-2.77%	-9.23%
	t=20	-0.06%	0.10%	1.80%	-4.96%	-4.42%	-18.61%
Real GDP	t=1	36.56%	32.53%	32.27%	36.56%	32.53%	32.27%
	t=5	-0.18%	0.42%	1.49%	-0.92%	-0.18%	0.17%
	t=15	-0.13%	0.31%	1.19%	-2.90%	-1.76%	-3.42%
	t=20	-0.11%	0.26%	1.06%	-3.74%	-2.37%	-2.01%
Total Investment	t=1	-12.00%	23.31%	23.04%	-12.00%	23.31%	23.04%
	t=5	-0.30%	0.63%	-0.81%	-1.62%	-0.53%	-8.92%
	t=15	-0.21%	0.45%	-1.54%	-6.10%	-4.60%	-40.62%
	t=20	-0.18%	0.38%	-1.85%	-8.83%	-7.02%	-64.85%
Real Disposable Household Income (rural)	t=1	13.93%	6.58%	5.79%	13.93%	6.58%	5.79%
	t=5	-0.41%	0.90%	-3.33%	-0.78%	0.63%	-8.36%
	t=15	-0.29%	0.65%	-4.17%	-2.04%	-0.43%	-31.43%
	t=20	-0.24%	0.56%	-4.52%	-2.82%	-0.98%	-47.28%
Real Disposable Household Income (urban unskilled)	t=1	-3.67%	4.05%	4.98%	-3.67%	4.05%	4.98%
	t=5	-0.02%	0.01%	14.61%	-3.07%	-2.72%	13.59%
	t=15	-0.02%	0.00%	14.68%	-12.78%	-11.45%	17.85%
	t=20	-0.02%	0.00%	14.70%	-18.28%	-16.44%	20.60%
Real Disposable Household Income (urban skilled)	t=1	-8.79%	-1.73%	-1.00%	-8.79%	-1.73%	-1.00%
	t=5	0.01%	-0.06%	15.09%	-2.31%	-2.18%	15.69%
	t=15	0.00%	-0.05%	15.25%	-10.02%	-9.23%	26.86%
	t=20	0.00%	-0.05%	15.32%	-14.60%	-13.47%	35.48%
Exports (excluding Oil)	t=1	-25.23%	-21.36%	-21.33%	-25.23%	-21.36%	-21.33%
	t=5	-0.49%	1.04%	3.61%	-3.06%	-1.21%	-3.82%
	t=15	-0.35%	0.75%	2.69%	-11.29%	-8.58%	-28.48%
	t=20	-0.29%	0.64%	2.29%	-15.97%	-12.70%	-44.21%

Simulation set (2a) through to (2c) allow for LBD externalities in tradables. It is immediately clear that the oil discovery has more profound negative effects on real non-oil GDP over the 20 year period which is negative in all three policy scenarios. While real GDP declines by the least when the revenues are used to increase public infrastructure investment, this is at the expense of exports which see a 44 per cent decline. The LBD scenarios introduce the classic 'Dutch disease' effects of a natural resource discovery.

The effects on real disposable incomes are consistent with an internal terms of trade effect resulting from the interaction between an initial spending effect and a subsequent supply response in each sector. The tradable nature of manufactures means that the supply schedule is virtually horizontal. Demand for food and services are decreasing in price while the supply schedules are upward sloping but steeper for food, reflecting the rigid unskilled rural labour market. Public infrastructure investment increases demand across all sectors putting upward pressure on domestic prices, the spending effect. The supply response is sector specific. Manufacturing output increases to meet demand, but given the price-taking property in the tradables sector, there is no price response. On the other hand the supply schedules in food and services shift out putting downward pressure on prices. The ultimate effect on the price of food and services depends on the slopes of these supply schedules. With a steeper schedule in food price falls over the medium-term while the services price remains above its initial level. Rural households suffer the most under the public infrastructure investment scenario, as they are net sellers of food, while unskilled urban household's benefit as they are net sellers of services. Skilled urban households, being the only owners of private capital, benefit most from the public infrastructure investment which increases the returns to private factors of production. The opposite is true for the consumption scenario where the increase in aggregate demand drives up the price of food more than other goods, therefore benefiting rural more than urban households.

5.2 Unbalanced Returns to Public Infrastructure & Use of the Oil Fund

We now consider the effects of investing in public infrastructure which continues to exhibit increasing returns to production but is allowed to do so in a non-neutral manner. In addition, the insulating properties of the foreign Oil Fund are investigated. Table 3 present the results for scenario (c), i.e. revenues used to increase public infrastructure investment, allowing with LBD effects in tradables, but with public infrastructure conferring unbalanced increasing returns to production.

Scenario set (3) allows for these increasing returns to be biased towards the tradable sector while scenario set (4) allow for a non-tradables bias. In each simulation the proportion of government oil revenues actually used to invest in infrastructure is varied from 20% through

Table 3: Increase Public Infrastructure (Tradables and Non-Tradables Bias) – Learning-By-Doing on

	Period	3a	3b	3c	3d	3e	4a	4b	4c	4d	4e
Key Model Parameters											
Learning-By-Doing Spillovers in Ts		On	On	On	On	On	On	On	On	On	On
Return to Public Infrastructure		Ts bias	Ts bias	Ts bias	Ts bias	Ts bias	NTs bias	NTs bias	NTs bias	NTs bias	NTs bias
Elasticity of Substitution (CES)		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Elasticity of Transformation (CET)		0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Proportion of Government Revenues Used		20%	40%	60%	80%	100%	20%	40%	60%	80%	100%
Macroeconomic Variables											
Real Exchange Rate	t=1	-5.14%	-9.97%	-14.48%	-18.70%	-22.62%	-5.14%	-9.97%	-14.48%	-18.70%	-22.62%
	t=5	-4.09%	-8.02%	-11.76%	-15.33%	3.81%	-3.94%	-7.74%	-11.36%	-14.83%	-4.79%
	t=15	-1.14%	5.93%	5.11%	4.76%	4.31%	-4.98%	-8.32%	-13.21%	-17.88%	-21.43%
	t=20	0.69%	7.44%	7.45%	7.11%	6.47%	-7.13%	-13.81%	-23.52%	-31.82%	-37.74%
Real GDP	t=1	5.88%	12.07%	18.55%	25.29%	32.27%	5.88%	12.07%	18.55%	25.29%	32.27%
	t=5	6.80%	14.00%	21.55%	29.47%	3.41%	6.59%	13.53%	20.82%	28.47%	-1.23%
	t=15	9.66%	5.79%	4.26%	3.55%	2.66%	6.00%	-1.03%	-1.65%	-0.97%	0.13%
	t=20	11.54%	6.81%	5.14%	4.18%	2.83%	5.15%	-1.19%	1.43%	6.55%	11.79%
Total Investment	t=1	5.92%	11.11%	15.66%	19.61%	23.04%	5.92%	11.11%	15.66%	19.61%	23.04%
	t=5	9.03%	17.68%	25.90%	33.72%	8.67%	9.57%	18.82%	27.73%	36.30%	-25.27%
	t=15	18.12%	17.01%	13.80%	12.35%	10.58%	1.48%	-37.02%	-49.71%	-60.94%	-68.71%
	t=20	23.61%	20.21%	18.13%	16.36%	13.74%	-9.05%	-52.15%	-73.35%	-88.64%	-98.21%
Real Disposable Household Income (rural)	t=1	1.09%	2.23%	3.40%	4.59%	5.79%	1.09%	2.23%	3.40%	4.59%	5.79%
	t=5	2.69%	5.40%	8.12%	10.86%	3.33%	3.46%	6.94%	10.44%	13.96%	-17.29%
	t=15	7.17%	8.57%	5.56%	4.13%	2.16%	-3.13%	-24.23%	-32.46%	-38.97%	-43.17%
	t=20	9.57%	9.99%	7.21%	5.18%	2.12%	-11.15%	-34.47%	-46.26%	-53.56%	-57.74%
Real Disposable Household Income (urban unskilled)	t=1	1.10%	2.15%	3.14%	4.09%	4.98%	1.10%	2.15%	3.14%	4.09%	4.98%
	t=5	3.58%	7.14%	10.67%	14.16%	13.34%	1.96%	3.85%	5.68%	7.46%	12.81%
	t=15	11.58%	16.71%	15.35%	14.86%	14.53%	8.74%	15.19%	14.18%	13.75%	13.28%
	t=20	17.68%	21.16%	21.00%	20.74%	20.36%	13.84%	16.48%	14.82%	13.16%	11.74%
Real Disposable Household Income (urban skilled)	t=1	-0.23%	-0.44%	-0.64%	-0.83%	-1.00%	-0.23%	-0.44%	-0.64%	-0.83%	-1.00%
	t=5	1.81%	3.61%	5.40%	7.18%	11.85%	0.57%	1.13%	1.66%	2.19%	18.54%
	t=15	8.32%	13.61%	12.73%	12.44%	12.33%	9.35%	23.72%	25.36%	27.43%	28.71%
	t=20	13.20%	17.30%	17.69%	17.66%	17.60%	16.61%	28.40%	31.43%	33.09%	33.59%
Exports (excluding Oil)	t=1	-4.85%	-9.39%	-13.65%	-17.63%	-21.33%	-4.85%	-9.39%	-13.65%	-17.63%	-21.33%
	t=5	-1.65%	-3.39%	-5.15%	-6.93%	11.49%	-1.74%	-3.55%	-5.38%	-7.23%	-16.46%
	t=15	8.06%	20.28%	15.99%	14.09%	11.65%	-7.48%	-24.35%	-34.49%	-42.33%	-47.48%
	t=20	14.67%	25.49%	22.59%	20.19%	16.45%	-14.82%	-35.41%	-50.03%	-59.54%	-65.26%

to 100%, i.e. scenarios (a) to (e). Once again, the percentage change in the variable is reported relative to the initial period, i.e. the calibration period (t=0).

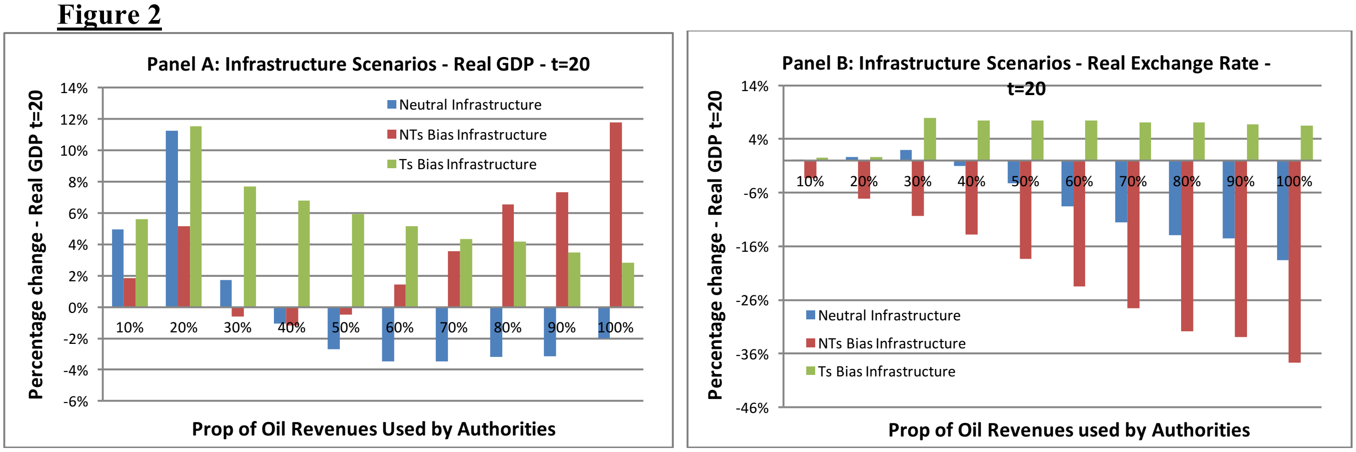
Under the alternative productivity biases of public infrastructure, the oil fund plays an important insulator role in light of the revenue windfall. Columns (3a) and (4a), where only 20% of government oil revenues are used in each period, results in the least distortion to the economy, and provides a smooth profile for government expenditure, while the impacts become more severe as we move from (a) to (e). Scenario set (3) and (4) have broadly the same impact on the real exchange rate in the initial periods, i.e. a real exchange rate appreciation.

When public infrastructure is biased towards non-tradables, the spending effect discussed in section 5.1 is exacerbated as the outward shift in the production possibility frontier (PPF) is concentrated on non-tradables (i.e. food and services). The real exchange rate appreciation is now more severe and is met by a continued contraction in exports, sucking labour out of tradables. The real non-oil GDP growth is due to the boom in non-tradables. In contrast, when the bias is towards the tradable sector public infrastructure investment overcomes the negative LBD effects. The real exchange rate recovers over the medium-term, even depreciating, and is met by growth in exports of between 14 and 25 per cent depending on the use of the oil fund.

Both scenario sets have the potential to yield similar impacts on real non-oil GDP over the medium-term. Now however, achieving maximum growth depends heavily on the use of the oil fund. If public infrastructure is biased towards tradables (scenario set 3) a conservative approach to the amounts of oil revenues used in each period is required to achieve maximum growth over the medium-term. The opposite is true if public infrastructure is biased towards non-tradables (scenario set 4). Figure 2 contrasts these two cases with neutral infrastructure case in table 1, column (2c), showing the effects on real GDP (panel A) and the real exchange rate (Panel B) at t=20.

Real GDP peaks when 20% of the government oil revenues are used each period, when public infrastructure is biased towards tradables. On the other hand, when public infrastructure is biased towards non-tradables there is an initial peak at 20% and a larger peak at 100%, with negative growth in between. In this case, real GDP is propped up only by large public investment programs which increase the value added of non-tradables. When the impact of public infrastructure is balanced, real GDP peaks at 20% but falls dramatically thereafter and remains negative through to 100% of oil revenues being used each period.

Figure 2

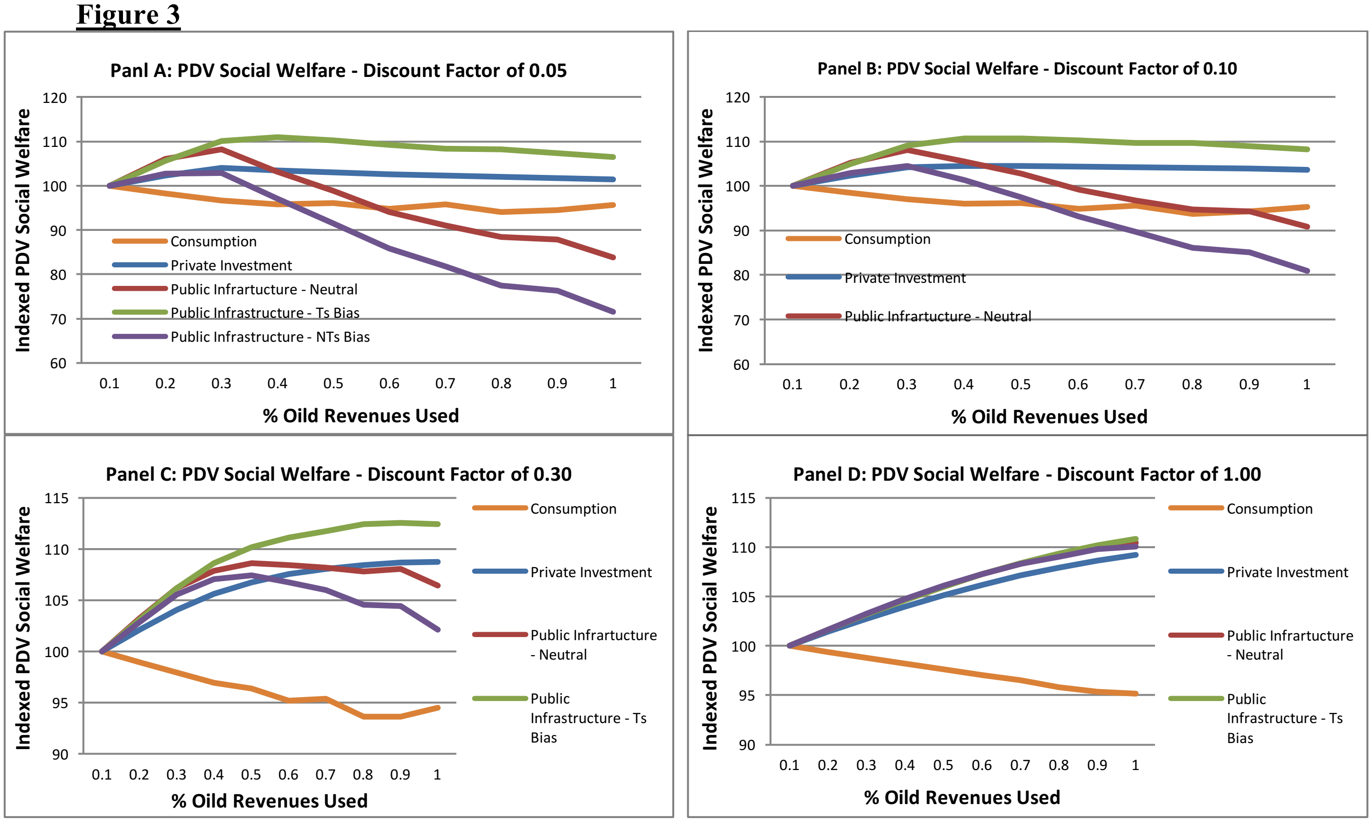


The effects on disposable household income also differs between scenario sets (3) and (4). When infrastructure is tradables biased, real disposable incomes for all household types increase in the medium-term, and are now largest for urban unskilled households (17 – 21 per cent depending on use of Oil Fund). The outward shift in the PPF is now concentrated on tradables allowing LBD[30] to kick in and depreciating the real exchange rate over the medium-term. When infrastructure is non-tradables biased the outward shit in the PPF exaggerates the effects discussed in section 5.1 with urban household benefiting once again at the expense of rural households.

5.3 Welfare & Political Discount Rates

The present discounted value (PDV) of social welfare over the whole simulation period is calculated using equation [29] in section 4.7. The political discount rate is likely to vary depending on the level of development of a country and the degree of political stability and quality of governance. Figure 3 presents the PDV of social welfare under the various policy scenarios given four different discount rates, 0.05, 0.10, 0.30 and 1.00. In each case LBD in tradables is turned on.

Figure 3



Assuming that the political discount rate is low, i.e. authorities are relatively patient, the optimal proportion of government oil revenues used to implement policy is low. Alternatively, if high

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[30] Note here that the LBD externality applies to both food and manufacturing sectors, i.e. all tradable sectors.

proportions of oil revenues are used in each period, projects that increase tradable-biased infrastructure and private investment should be favoured over non-tradable-biased or neutral infrastructure. In other words, relatively patient societies should make use of the creation of a foreign Oil Fund to insulate the economy and smooth oil revenue expenditure. This would be the case for more developed and politically stable nations.

6 Conclusions and Extensions

The discovery of oil in Uganda has had a mixed reception. While the authorities see this as an opportunity to boost economic growth and development, much of the local population are sceptical about what benefits, if any, they will see. This scepticism is not unfounded. Natural resources have the potential to improve the livelihoods of the poor, increase economic growth and intensify development efforts, however the track record in Africa and much of the developing world has been poor. Much attention in the literature has been paid to the different channels through which natural resource abundance impacts on a variety of development indicators. These include, the traditional macroeconomic impacts, concerns about political stability and corruption, risks of conflict, and the role of human capital. Both theory and evidence suggest that natural resource abundance is neither necessary nor sufficient for development. In addition, recent work has highlighted the differences in the management strategy of revenue windfalls between rich and poor countries.

This paper builds on some key findings within the literature. Using a dynamic equilibrium model for Uganda, we concentrate on expenditure policy options available to developing country governments in light of a resource discovery. In addition, we formally model the creation of an Oil Fund, held abroad, allowing the authorities to smooth expenditure decisions over different time horizons. We find that classic 'Dutch disease' effects are present in the medium-term when learning-by-doing exists in exports. When public infrastructure creates unbalanced productivity gains to different sectors, the use of the Oil Fund becomes important beyond its insulating properties. When authorities are relatively impatient, the incentive is to skew expenditure towards the present which comes at the cost of future generations' welfare and negative distributional implications for the poor. In this case, economic growth requires high investment in non-tradables coupled with higher domestic prices and a reduction in exports. If on the other hand, the authorities have a low discount rate, the incentive to smooth expenditure and maximise social welfare over the medium-term becomes compatible with high economic growth, strong export performance and higher incomes for the rural poor. There is an element of irony to this result. It is usually argued that a socially suboptimal outcome prevails when households make expenditure smoothing decisions over finite horizons. This provides one motivation for government intervention. However developing country governments, due to political instability and weak institutions, may in fact be more impatient than households.

Due to time and space constraints, a number of important extensions have been ignored in this analysis of a natural resource discovery. First, the model used focuses on fiscal policy and negates any role for monetary and exchange rate policy or trade policy. Second, the insulating properties of the Oil Fund are purely in relation to demand side effects of a revenue windfall. An arguably more important role is that of risk spreading. From a portfolio management perspective, the Oil Fund trades-off domestic vs. foreign investment based on the correlation between the domestic and foreign economies and the pass-through of shocks. Third, the transitory effects of setting up an oil producing sector, which have been ignored in this paper, are likely to have important implications for policy. This list is by no means exhaustive.

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Appendix

Figure A1: Map of East African Rift Basin, Uganda and the Albertine Graben