The economic impacts of newly discovered oil in Uganda, using a recursive dynamic CGE model

(Draft)

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1. Introduction

Oil and gas reserves have recently been discovered in Ghana, Ethiopia, Sierra Leone and Uganda. The management of these resources are important as these discoveries provide opportunities to engage on paths of sustainable growth and development which could facilitate poverty reduction. According to Aryeetey and Asmah (2011), Ghana and Uganda are two of the countries that are currently attracting most attention of foreign oil corporations. On 17 September 2012 Uganda officially revised upwards its estimated oil reserves to 3.5 billion barrels after appraisal activity in two blocks revealed more crude deposits. "However, production has been repeatedly delayed by contractual disagreements, tax disputes and infrastructure setbacks" (Biryabarema, 2012).

There is not a strong empirical relationship between oil rents and development in African countries. Even though some African countries are endowed with large and rare natural resources, 22 out of 24 nations in 2009 that were identified as having "Low Human Development" according to the United Nations' Human Development Index, were located in Sub-Saharan Africa (Tuokuu, 2012). Hence, resource endowment does not necessarily translate into development. Indeed, according to Aryeetey and Asham (2011) oil, gas and mineral wealth have instead become associated with high poverty rates, weak state institutions, corruption and conflict. For example, The Democratic Republic of Condo (DRC) is richly endowed with mineral and forest resources. It is estimated that the Congo basin alone can produce enough food to feed nearly half the global population (Tuokuu, 2012). In spite of these resources, the average Congalese earns and annual income of less than US100$ and State revenue is less than US$1billion. It is also common for productive agricultural and manufacturing sectors to move away from their successful operations toward mining production. For example, the cocoa farms in Ghana are now used for mining activities. Not only does this impact of the production and exports of cocoa, it also affects the land owner's future prospects. Students whose families farmed with cocoa could apply for scholarships from the Cocoa Marketing Board. Now that the land is no longer used for cocoa production, students are no longer eligible for these scholarships. Other African countries with similar statistics include Sierra Leone, Chad, Nigeria, Angola and Mozambique.

Another outcome of resource extraction is the phenomenon called Dutch disease. Some African countries seem more vulnerable due to their high degree of dependence on exports and fiscal revenues. Corden (1984) summarises the effects related to the disease into two effects, namely, the "Spending Effect" and the "Resource Movement Effect". Extra income is generated in the "Booming Sector" which is spent in the domestic economy by either the owners of the factors or by the government through being collected in taxes and then spent. If the income elasticity of demand for non-tradeables is positive, their prices will rise relative to the prices of tradeables, which results in a real appreciation. This will draw resources out of the booming sector and other tradeables into the non-tradeables, as well as shifting demand away from non-tradeables towards the booming sector and other tradeables (Corden, 1984).

The Resource Movement Effect takes place because the marginal product of labour rises in the booming sector as a result of the boom so that the demand for labour in the booming sector rises, inducing movement of labour away from other industries. This effect has two parts. Firstly, the movement of labour into the booming sector lowers output in the sectors losing labour. Second, there is a movement of labour out of non-tradeables into the booming sector (Corden, 1984).

In this paper we model the economic impacts of newly discovered oil by using a dynamic CGE model for Uganda. We model the economic impact in two phases. Firstly we model the construction phase via an expansion in investment in the oil sector. Secondly, we evaluate the impact during the operational phase. In this phase we increase the exports of petroleum products.

The remainder of the paper is structured as follows. Section 2 gives an overview of the oil sector in Uganda. Section 3 describes previous studies on natural resource extraction and the Dutch disease. In Section 4, we describe the theoretical structure of the economic model, UgAGE-D. Section 5 describes the database that forms the initial solution to the model. In Section 6 we describe the various components in designing the simulation. Firstly, we describe a simple back-of-the-envelope that proves useful in understanding the simulation results. We then proceed in explain the economic consequences of the construction and operational phase. The paper ends with a conclusion.

2. An overview of the oil sector in Uganda

2.1 Where is the oil and how much oil is available

In 2006 the Ugandan government announced that commercially viable oil reserves were discovered in the Albertine rift of Western Uganda. See Map 1 for the geographical location of the Albertine Graben. This area runs along Ugnada's western border with the Democratic Republic of Congo (DRC) and is approximately 1300 kilometres from the coast. To date 20 oil and/or gas discoveries have been made. See Map 2 for oil discoveries. The estimated reserves in place are about 3.5 billion barrels of STOIIP (Stock Tank Oil Initially in Place).[1] The estimated barrels of recoverable oil equivalent are approximately 1 billion barrels. Currently less than 40 per cent of the Albertine Graben has been evaluated (Kabanda, 2012).

2.2 Licence areas, licenced operators and active production sharing agreements

Currently the Albertine Graben is subdivided into 17 licenced areas (see Map 3). There are five Active Production Sharing Agreements (PSAs). There are four licenced operators, namely Tullow, Total, CNOOC and Dominion. Appendix 1 includes a description of the operators' African business. Since

[1] Oil in place is the total hydrocarbon content of an oil reservoir and is often abbreviated STOIIP referring to the oil in place before the commencement of production. In this case, stock tank refers to the storage vessel (often notational) containing the oil after production. Oil in place must not be confused with oil reserves, that is, the technical and economically recoverable portion of oil volume in the reservoir. Current recovery factors for oil fields around the world typically range between 10 and 60% - some over 80%. The wide variance is due to largely to the diversity of fluid and reservoir characteristics for different deposits.

the discovery of oil in 2006, the process of formulating a National oil and gas policy was started and subsequently licensing was suspended (PEPD, 2012: 14). A new National oil and gas policy was enacted in 2008. This policy recommends (1) competitive bidding for future licensing in Uganda and (2) new regulatory and institutional framework for Uganda (PEPD, 2012: 14; Kabanda, 2012).

2.3 Investment in the oil sector

In Uganda there has been a sharp increase in investments since the first major discovery in 2006. To date risk capital to the value of US$1.5 billion has been invested in seismic surveys, exploratory and appraisal drilling.[2] Investment is expected to increase due to further field development and exploration, joint ventures and farm-in arrangements in existing licences, the production and processing of the crude oil, transportation facilitates and services related to this field (engineering, pipelines, storages facilities and refinery construction) (PEPD, 2012:14). The first oil is expected in 2017.

The East African Community (EAC) finalised the *Strategy for the development of regional refineries* in 2008. This strategy recommends the development of additional refining capacity in the EAC region. Based on the recommendation of this study, a feasibility study analysing the construction of a pipeline exporting crude oil against developing a refinery was conducted for Uganda in 2010.[3] This study reports that the development of a refinery in Uganda was economically more feasible than building pipelines to Mombasa refinery (PEPD, 2012: 15, Matsiko, 2012; The East African, 2012; Biryabarema, 2012). The study found that building a small refinery with a capacity of 15,000 barrels per day, which is Uganda's daily consumption rate, would cost approximately $1 billion whereas transporting the crude oil by pipeline to Mombasa would cost $1.7 billion while the southern route to Tanzania (Dar es Salaam) would cost $2.3 billion (The East African).

[2] Costs so far can be classified as "finding costs" which on a global scale range between $5-$25 per barrel. Finding costs refers to the cost of finding commercial reserves of oil in USD per barrel.
[3] The feasibility study was completed by Foster Wheeler.

Presently, neither the Mombasa refinery nor Tanzania has the capacity to refine Uganda's oil, which is said to be very waxy and heavy with sulphuric acids. The type of oil in Uganda would make it expensive to transport it via pipelines. The waxy crude oil solidifies at room temperature, and therefore the pipeline has to be heated and every 25 kilometres a station has to be installed to remove all the wax from the pipeline (The East African, 2012).

There is a difference in opinion in what the Ugandan government and the oil companies feel is a viable size for a refinery. The oil companies prefer to finance a small refinery of 20,000 b/d that would cost approximately $600 million. Their aim is to combine the refinery with a pipeline that would concurrently export crude oil from Uganda (Matsiko, 2012). The government's plan is to develop a 60,000 b/d refinery that will be expanded to 120,000 b/d and then 180,000 b/d. At 180,000 b/d the Uganda refinery will be the fourth largest on the African continent. See Table 2 for a comparison between oil reserves and refinery capacity per day. Libya has Africa's largest oil reserves followed by Nigeria and Angola. Algeria Skikda Refinery is the largest refinery in Africa followed by Libya Ras Lanuf and Nigeria's Port Harcourt I & II refineries which produces at only 25% of their capacity. At 180,000 b/d, Uganda's refinery will be the fourth largest on the African continent even though there oil reserves are much less than Libya, Nigeria and Angola (Matsiko, 2012). The government is looking into a public-private (40:60) partnership to financing the refinery.

Table 2 here

2.4 Benefits of a refinery in Uganda

Building a refinery in Uganda would create many spin-offs such as employment and secondary industrial services. While oil companies prefer crude exports because they can recoup their investment faster, building a refinery would save over a billion dollars annually through direct benefits to the economy, generate tax revenues, lower petroleum prices, lead to savings on the import of petroleum products and improve infrastructure which will decrease the cost of doing business. It will also create stability in the supply of petroleum products to Uganda and lessen their dependence on the import of petroleum products from other countries such as Kenya.[4]

Why does Uganda want such a big refinery? The government is confident that proven reserves will increase from 3.5 billion barrels to 8 billion or even 10 billion (Matsiko, 2012). As mentioned before only 40% of the area with potential oil and gas has been explored. Of the 77 oil wells drilled, 70 wells encountered oil and gas. This is a drilling success rate of 90%, which is higher than the world average of 10%. Given these statistics, the governments' confidence becomes clear (Matsiko, 2012).

2.5 Issues relating to the refinery

There are critics to Uganda's refinery project. Firstly, the World Bank questions the need and viability of such a large refinery in a landlocked country. Uganda would still need some way of transporting the excess crude oil and petroleum to their markets. Secondly, Uganda is not the only East African country that discovered oil. Kenya and Tanzania are also discovering oil. Thirdly, the critics also argue that the refinery will diminish oil volumes that would have been exported (which impacts on oil revenue) and at the same time fail to offset domestic fuel prices (Matsiko, 2012). In these situations, governments, such as in Nigeria and Iran reduce the price of crude oil to boost the domestic refinery and use the revenue from the crude that is exported as subsidies for local consumers. These subsidies keep the price artificially low and when the subsidies are removed, prices increase leaving the local population unhappy (Matsiko, 2012). Fourthly, Uganda was supposedly going to refine some of Southern Sudan's oil. However, Southern Sudan and Ethiopia entered into a deal with Kenya which would lock Uganda out of the Lamu Port and Lamu Southern Sudan-Ethiopia Transport project. LAPSSET is a project involving pipelines, roads and an oil refinery at the Lamu port of Kenya (See Map 1a). Uganda is not seeing this project as a

[4] Kenya experienced riots in 2007 which meant that Uganda was cut off from the supply of petroleum products (Matsiko, 2012).

threat. Fifthly, the government has earmarked 29 square kilometres for the refinery project. This means that approximately 8,000 people will be evicted from their land and homes. Some people will be reallocated and others will be compensated. People losing their homes are worried that they will not receive adequate compensation for their land and feel that the government is not open enough about their dealings with the communities (Byaruhanga, 2012).

3. Previous studies on natural resource extraction and the Dutch Disease

Fielding and Gibson found that CGE models of the macroeconomic impact of aid inflows produced a wide variety of results. They refer to papers by Bandara (1995), Jemio and Jansen (1993), Jemio and Vos (1993) and Vos (1998) indicating that in countries such as Mexico, Sri Lanka and Thailand, traded goods sector investment is likely to be high enough to guarantee an expansion of this sector following an increase in aid inflows. By contrast, in countries such as Pakistan and the Philippines, they found a standard Dutch Disease effect: "an increase in aid inflows leads to a real exchange rate appreciation and a fall in traded goods production. Such heterogeneity is consistent with Adam and Bevan's (2004) model, calibrated to Ugandan data, in which the composition of aid expenditure makes a large difference to the response of sectoral output and relative prices. This dynamic CGE model also suggests that there will often be some real exchange rate overshooting, with a larger appreciation in the short run than in the steady state" (Fielding & Gibson, 2011).

Benjamin, Devarajan and Weiner (1987) built a CGE model for Cameroon, and found that one of the standard Dutch disease results could be reversed when certain features of developing countries are incorporated. They found that if the assumption of perfect substitutability between domestic and imported goods is dropped, not all the traded goods sectors will contract (Benjamin et al., 1987).

Benjamin (1990) claims that the traditional treatment of the Dutch Disease would only consider the composition of output between traded and non-traded goods but does not include the trade-off between consumption and investment. She adds the investment dimension in her CGE model of the oil boom in Cameroon, and finds that "the composition of aggregate demand responds to factor prices driving investment decisions" (Benjamin, 1990).

3.1 Possible solutions to the Dutch Disease problem

Uganda will need to put policy measures in place to avoid any potentially negative consequences, such as Dutch disease. Fortunately there is now a broad understanding of some of the measures that need to be put in place in order to manage expectations and avoid the resource curse. Botswana, Canada, Australia and Norway are among the countries that have effectively managed their natural resources to advance development. Aryeetey and Asmah list a few common themes on how to avoid the resource curse as follows:

1. The absence of a long-term national development strategy with broad consensus on spending priorities may encourage wrong investment decisions, wastefulness and mismanagement of revenues with serious negative implications for the economy.
2. The design and implementation of appropriate policies matter. For example, fiscal strategies that smooth cycles have been raised in the policy discussion. A subsidy or tax relief for the non-resource export sectors that are hurt by a loss of competitiveness due to the natural resource bonanza and the spill-over effects have proven to be worthwhile.
3. With regards to how governments can use revenues from natural resources, the consensus is to invest in the long-term accumulation of all forms of capital (human, physical and institutional), as opposed to financing current consumption. Spending and investment in education, health and infrastructure development is certainly a good thing. But if it is done in isolation without adequate spending on the

tradable sector, it could adversely affect the employment and welfare of people engaged in the tradable sector.

4. Strategies should also take into account the fact that some resources are non-renewable. Thus, there is the need to limit fiscal discretion in order to avoid the over-use of revenues. In this regard, it may help to put some of the revenues into fiscal reserves or sovereign wealth funds to avoid over-use of revenues and to ensure that the interests of future generations are safeguarded. (Aryeetey, E & Asmah, E, 2011).

Tuokuu adds three sets of solutions to the Dutch Disease problem, namely (i) improved education, (ii) investment in technology, industry and scientific research, and (iii) good governance and good state institutions (Tuokuu, 2012).

4. The UgAGE-D model

The UgAGE-D model of Uganda consists of three modules. The first module describes the behaviour of industries, investors, households, the government and exporters and is based on the theoretical structure of the ORANI-G model (Dixon et al., 1982). The second module draws on additional data included in the social accounting matrix (SAM) of Uganda, which captures transfers of funds between agents in the domestic and foreign economies. The final module includes equations describing the dynamic mechanisms in the model. These equations explain the stock-flow relationship between investment and capital as well as the relationship between wage growth and employment.

4.1 Core module

The first part of the theoretical structure of the UgAGE-D model is based on ORANI-G and forms the core structure of the model. UgAGE-D models production of 34 commodities by 34 industries. Three primary factors are identified: land, capital and labour. Labour is further distinguished by 16 occupational types. Labour is mobile across sectors. The model has one representative household and one central government. Optimising behaviour governs decision-making by the household and firms. Industries minimise costs subject to given input prices and a constant returns to scale production function. The household is assumed to be a utility maximiser. Units of new industry-specific capital are cost minimising combinations of Ugandan and foreign commodities. We assume that domestic and imported varieties of commodities are imperfect substitutes for each other, with this modelled via constant elasticity of substitution (CES) functions. The export demand for any Ugandan commodity is inversely related to its foreign-currency price. UgAGE-D models the consumption of commodities by government as well as indirect taxes. All sectors are competitive and all commodity markets clear. For a detailed description ORANI-G, see Dixon et al. (1982).

4.2. SAM detail

The second part of UgAGE-D models the SAM detail not captured in the core structure of the model.[5] We model the income and expenditure items of four entities, namely (1) enterprises, (2) households, (3) the government and (4) the account with the rest of the world. See Table 1 for a representation of the SAM. We briefly describe each of these accounts.

Table 1 here

4.2.1 Enterprise account

The enterprises account models the income and expenditure of all public and private corporations in the economy. As shown in Table 1, row 11 shows that enterprises derive their income from factors (GOS) and transfers from households, other enterprises, the government and the rest of the world.

VENT = VENTGOS + VENTHOU + VENTENT + VENTGOV + VENTROW

[5] This SAM-extension part of the UgAGE-D model is based on PHILGEM. PHILGEM is an ORANI-G styled model with additional equations describing the flow between economic agents constructed for the Philippines (Corong and Horridge, 2011).

where

VENT is the total income of enterprises

VENTGOS is the enterprise receipts from gross operating surplus

VENTHOU is the enterprise receipts from households

VENTENT is the enterprise receipts from other enterprises

VENTGOV is the enterprise receipts from the government

VENTROW is the enterprise receipts from the rest of the world

The income equation postulates that the percentage change in each household's property payments to enterprises is directly related to their respective incomes from their GOS; payments received from other enterprises are influenced by the movement in the paying enterprise post-tax income; the percentage change in government payments to enterprise payments is related to government income and the ROW transfers to enterprises are influenced by the movement of the local economy's gross domestic product.

The payments by enterprises are listed in Table 1, column 11 and expressed as:

VENTEXP = VHOUENT + VGOVENT + VTAXENT + VENTENT + VROWENT

where

VENTEXP is the total payments of enterprises

VHOUENT is the enterprises payments to households

VGOVENT is the non-tax transfers to the government from enterprises

VTAXENT is the direct tax payment from enterprises

VENTENT is the enterprise payments from other enterprises

VROWENT is payments to the rest of the world from enterprises

The percentage change in the direct tax payments follows the percentage change in enterprise income. The percentage change in VGOVENT, VHOUENT and VROWENT is determined by the percentage change in the post-tax income of enterprises. Enterprise post-tax income is given as:

VENT_POSTTAX = VENT – VTAXENT

where
VENT_POSTTAX   is the post-tax income
VENT is total enterprise income
VTAXENT is direct tax paid to the government

Enterprise savings (retained earnings) is determined as the difference between income and expenditure.

4.2.2. Household account

Household income is derived from factors and from transfers from other agents (Table 1, row 10). Household income is defined as:

VHOUINC = VHOULAB + VHOUGOS + VHOUHOU + VHOUGOV + VHOUROW

where
VHOUINC   is the pre-tax household income
VHOULAB   is labour income
VHOUGOS is the household receipts from gross operating surplus
VHOUHOU is the intra-household transfers
VHOUGOV is the government transfers to households
VHOUROW is household receipts from the rest of the world

The percentage change in government transfers to households and household receipts from the rest of the world follow movements in GDP. The percentage change in the transfers to households from enterprises is linked to the post tax income from enterprises. The transfers from household to another are proportional to the post-tax income of the donor. Disposable income is derived after deducting direct income tax and other non-tax payments to the government.

Household spending is defined as:

VEXPHOU = V3TOT + VHOUHOU + VGOVHOU + VTAXHOU + VENTHOU + VROWHOU

where
VEXPHOU is the total household expenditure
V3TOT is total household consumption
VHOUHOU is the household payments to other households
VGOVHOU is the non-tax payments to the government from households
VTAXHOU is the income tax payments from households
VENTHOU is the household payments to enterprises
VROWHOU is the household payments to the rest of the world

Households mainly spend their income on final consumption, which in the model is linked to disposable income. We postulate that the percentage change in intra-household transfers and transfers from households to the rest of the world follow the disposable income from the donor; percentage change in non-tax and tax payment to the government follows pre-tax household income and finally, the percentage change in transfers from households to enterprises follows the returns from GOS. Household savings is determined as difference between income and spending.

4.2.3. Government account

The elements of government income are listed Table 1, row 12 and is defined as:

VGOVINC = VTAXCOM + VGOVGOS + VTAXENT + VGOVENT + VGOVHOU + VTAXHOU + VGOVROW where

VGOVINC is government income

VTAXCOM is all indirect taxes

VGOVGOS is the government receipts from gross operating surplus

VTAXENT is the direct taxes received from enterprises

VGOVENT is the non-tax receipts from enterprises

VGOVHOU is household transfers to the government

VTAXHOU is the direct tax payments from households

VGOVROW is the payments to the government from the rest of the world

VTAXENT, VGOVENT, VGOVHOU are VTAXHOU are explained above. We postulate that government income from the rest of the world (VGOVROW) moves proportional to the change in domestic gross domestic product.

Government expenditure (Table 1, column 12) is defined as:

VCURGOV = V5TOT + VHOUGOV + VENTGOV + VROWGOV

where

VCURGOV is total government expenditure

V5TOT is total government consumption

VHOUGOV is the household receipts from the government

VENTGOV is the payments from government to enterprises

VROWGOV is the government payments to the rest of the world

The percentage change in VHOUGOV and VROWGOV are explained above. We postulate that the percentage change in the transfer payments to the rest of the world is proportional to the percentage change in gross domestic product. Government savings is calculated as the difference between income and expenditure.

4.2.4. Rest of the world

The final account is that of the rest of the world. Income to the rest of the world is listed in Table 1 row 15 and is defined as:

VINCROW = VIMP + VROWHOU + VROWENT + VROWGOV

where

VNCROW is the total rest of the world income

VIMP is export receipts from Uganda, i.e. Ugandan imports

VROWHOU is the rest of the world receipts from households

VROWENT is the rest of the world receipts from enterprises

VROWGOV is the rest of the world receipts from the Ugandan government

We postulate that the percentage change in transfers from households and enterprises follow their respective disposable incomes and the percentage change in transfers from the government follows GDP.

Spending by the rest of the world is illustrated in Table 1 column 15 and defined as:

VEXPROW = V4TOT + VGOVROW + VENTROW + VHOUROW

where

VEXPROW is total rest of the world expenditure

V4TOT is total exports

VGOVROW is the government receipts from the rest of the world

VENTROW is the enterprises receipts from the rest of the world

VHOUROW is the rest of the world payments to households

The percentage change in these variables is explained above. Foreign saving is calculated as the difference between foreign income and spending.

4.3. Dynamic mechanisms

The final part of UgAGE-D models the dynamic mechanisms related to capital accumulation and labour market adjustment. Capital accumulation is industry-specific and linked to industry-specific net investment. That is capital at the end of year t is equal to the start of the year value plus investment minus depreciation on existing capital stock. Changes in industry-specific investment are linked to changes in industry-specific rates of return.

UgAGE-D includes two investment rules specific to each industry. The first rule state that industry investment is positively related to rates of return. Industries with higher rates of return would therefore attract investment. The second rule is used to determine investment for those industries for which we deem the first rule to be inappropriate. These industries might be those where investment is determined by government policy. Investments for these industries follow the national trend. Industries that follow the second rule include electricity and water; construction, financial services, real estate, business services, public administration, education, health , community and social work and finally recreational services.

The real wage adjustment equation states that if end-of-the-period employment exceeds some trend level by x% then real wages will rise, during the period by α*x%. Since employment is negatively related to real wages, this mechanism causes employment to adjust towards the trend level.

5. Preparation of the UgAGE-D database

We briefly describe how we constructed the CGE database for the dynamic CGE model. The database consists of three parts: (1) core CGE database; (2) SAM data not included in the core CGE database; and (3) data related to the dynamic mechanisms in the model. The initial core database of a model is of importance because; (1) it contains information regarding the structure of the economy to be modelled in the base year; (2) it is the initial solution to the CGE model and (3) it can be supplemented by additional data relating to dynamic mechanisms to create a dynamic model or other detailed features modelled.

The building blocks for creating the CGE database are the 2002 Ugandan Supply-Use Table (SUT) and Social Accounting Matrix (SAM). The published data is not in the required format of the CGE database, and so much effort has gone into transforming the published data into the required format. For a description of the published Ugandan SUT , the issues identified in the data and the steps taken to transform the published data into the required CGE database. Of special interest in this paper is the mining sector. The published SUT contains information on one mining commodity[6] and four mining industries[7]. No explicit mining of raw oil is recorded in the 2002 SUT. We therefore split the mining sector into two final mining activities, namely *Raw Oil* and *Other Mining*. This process required the authors to make decisions on the cost and sales structure of the *Raw oil* sector.

The database is created for 2002 and updated, with the Adjuster program, to 2009 (Horridge, 2009). Based on the updated database and initial information in the 2002 SAM, we also created a 2009 SAM. We use additional data, not included in the core database, to extend the UgAGE-D model. The format of the 2009 SAM is illustrated in Figure 1. In general, the SAM tracks how income is generated and distributed. In Figure 2, the row values show how income is generated and the column values show how the expenditure. For example, row 9 shows the income sources of households as income generated from labour, mixed income, transfers from households (VHOUHOU), transfer from the government (VHOUGOV), transfers from enterprises (VHOUENT) and transfers from abroad (VHOUROW).

5.1 Structure of the CGE database

There are three parts to the CGE database. We describe each part below. The first part is the core CGE database. Its structure is illustrated in Figure 1 and is well documented (Dixon et al., 1982; Horridge, 2009). The model requires a core database with separate matrices for basic, tax and margin flows for both domestic and imported sources of commodities sold to domestic and foreign users, as well as matrices for the factors of production. The factors of production are labour, capital and land by industry. Two satellite matrices are included, namely the multi-product matrix and the

[6] Mining and quarrying.

[7] (1) Mining of non-ferrous metal ores, except uranium and thorium; (2) Quarrying of stone, sand and clay, (3) extraction of salt and (4) other mining and quarrying N.E.C.

tariffs matrix. All the matrices included in the core database (and illustrated in Figure 1) are observed in Table 1. Table 1 illustrates the format of the Ugandan SAM. In Table 1, all matrix names written in black in the white cells, appear in Figure 1 and is therefore already included in the core database. For example, the MAKE matrix appears as a satellite matrix in Figure 1. In Table 1, the MAKE matrix appears in row 3, column 1.

Figure 1 here

The second part of the database includes data from the SAM not accounted for in the core CGE database. The data captured in the second part of the database is shaded grey in the SAM (Figure 2). The shaded areas typically capture flows between agents in the economy. For example, income flows representing labour payments from the rest of the world to households (VHOUROW), or payments from the government to households (VHOUGOV).
The third part of the database captures information relating to the dynamic mechanisms in UgAGE-D. These matrices are not illustrated in Figures 1. The dynamic mechanisms consists of: (1) a stock/flow relationship between investments and capital stock; (2) a positive relationship between investment and the rate of profit; and (3) a link between wage growth and employment (Horridge, 2002).

5.2 Data sources

As mentioned above, our main source of information is the 2002 Ugandan SUT, supplemented with data adopted from the SAM and expert knowledge form UBOS. The supply table shows the domestic production of commodity *c* by industry *i* valued at basic prices, the value of imports of commodity *c*, as well as commodity-specific taxes and margins. The total supply of commodity *c* valued at purchasers' price is calculated by adding the commodity-specific basic values to the margins and taxes. In principle the total supply of commodities at purchasers' price is equal to the total use at purchasers' price. The use table contains information on the sales structure of commodities to final users as well as information on factor payments. The final users recorded in the SUT are 241 industries, 1 investor, 1 representative household, 1 exporter and the government. Factor payments are industry-specific labour payments and capital rental values. Production taxes are given by industry. We supplement the data in the SUT with data contained in the SAM. For example, the SUT only contains total labour payments by industry whereas the CGE model requires labour payments by occupation and industry. To create the required labour payment matrix (V1LAB) we adopt the industry-specific occupational shares from the SAM and multiply it with the industry-specific total labour payments observed in the SUT. We also use data from the GTAP database to create land rental values. We also drew upon the expert knowledge of our colleagues at UBOS. UBOS officials made suggestions on how to correct and adjust for misprints, perceived implausible numbers and negative flows.

5.3 Constructing the CGE database

The process of converting published data to a CGE database is largely determined by the differences between the published data and structure of the model database, as well as the perceived implausible data items and misprints in the SUT. Some of the data issues identified in the 2002 SUT include negative capital rental values (and some negative value added values), implausible production tax values and no values for land rentals. Other issues are for example that the indirect taxes are given by commodity only in the supply table. However, the tax matrices in Figure 1 show that the model requires tax matrices by commodity, source and user. We converted the published SUT tables to the required form in a number of data manipulating steps. In doing so, additional data from reputable sources were incorporated. We list the data manipulating steps below.

Step 1: Check published data for balancing conditions, identify misprints and negative flows.

Step 2: Reviewing factor payments (adjusting negative capital rentals, creating land rental payments, industry-specific labour payment adjustments and balancing the factor payment matrices) (Figure 1, rows 4-6).

Step 3: Adjust the multi-product matrix (Figure 1).

Step 4: Remove the remaining negative flows. Negative flows were identified in the intermediate use matrix as well as inventories for service commodities.

Step 5: Splitting flows into domestic and imported sources.

Step 6: Create margin matrices (Figure 1, row 2).

Step 7: Create indirect tax matrices (Figure 1, row 3).

Step 8: Creating the matrices for the basic flows.

Step 9: Create an industry dimension for the investments column.

Step 10: Final balancing of the database and run tests for model validity (Horridge, 2011).

After we created the CGE database using the 2002 SUT and SAM, we use the Adjuster program to update the database to 2009 (Horridge, 2009). We then proceed to create a 2009 SAM. We had no information on the 2009 values of the flows between economic agents in the domestic and foreign economies. We therefore assumed that the share of the relevant flow to GDP is the same in 2009 as it was in 2002.

As mentioned before, the published data do not include any information on the oil sector. Only one mining commodity and four mining industries are included in the SUT (see footnotes 1 and 2). Based on the SUT data we create two mining commodities and industries namely, *Raw oil* and *Other Mining*. The database shows that the sum of all mining sector outputs contributes approximately 0.3 per cent of total domestic output. To create the *Raw oil* sector we need to know something about the cost and sales structure of this sector. As the oil sector is a new sector in the Ugandan economy, we assume that the cost (input) structure is similar to the *Other mining* industry's cost (input) structure. To create small values for the oil sector we assume that value of the oil sector is 10 per cent of total mining. In terms of sales, we assume that all raw oil is used as an input to the refinery industry. The assumptions related to the cost and especially the sales structure of the *Raw oil* sector can be modified as more information is made available. This sector is capital intensive.

The final part of the CGE database relates to dynamic mechanisms in UgAGE-D. To parameterise these equations we require values for industry-specific capital stock, depreciation rates, gross rate of return as well as the capital growth rate.

6 Simulation design

Policy analysis with a dynamic CGE model requires two simulations. The first simulation is the baseline forecast or business-as-usual simulation. Our first simulation models the growth of the Ugandan economy over time in the absence of the policy change under consideration. The second simulation is the policy simulation. This simulation generates a second forecast that incorporates all the exogenous features of the baseline forecast, and now includes policy-related shocks reflecting the details of the policy under consideration. The impacts of a policy are typically reported as a percentage deviation away from the baseline forecast.

The IMF Uganda country report lists a number of major investment projects (IMF, 2011), which include the Karuma hydropower project, Kampala-Entebbe Expressway, exploration of oil reserves including the construction of a refinery and pipeline, and various tourism projects. We chose the oil investment project for our application because (1) oil production is set to be a key driver in achieving higher growth and (2) we were able to obtain preliminary information from the Petroleum Exploration and Production Department as well from our colleagues at the Ugandan Ministry of Finance.

In order to model the economic impacts of the exploration of new oil deposits in the Lake Albert area, this paper reports the results of dynamic simulations. In the short-run the simulations deal with the construction phase whereas the latter part of the simulations, resembling the long-run, deals with the operational phase.

Before we describe the simulation results, we present a back-of-the-envelope (BOTE) model. The BOTE model captures the underlying features and macroeconomic relationships in UgAGE-D and is useful in understanding the macroeconomic results. The BOTE model presented in Table 3 explains a standard short-run and "effective" long run closure.

Table 3 here

Equation (B.1) describes an economy-wide constant returns-to-scale production function, relating real GDP to inputs of capital (*K*), labour (*L*) and primary-factor technical change (*A*). Equation (B.2) describes real gross domestic product (*GDP*) from the expenditure side in constant price terms. Equation (B.3) relates the sum of private and public consumption to output (Y) via a given average propensity to consume (*APC*) as well as the terms of trade (TOT). Equation (B.4) relates aggregate import volumes to GDP and the terms of trade (*TOT*). Equation (B.5) defines the terms of trade as negatively related to exports (X) and a shift variable (V)[8]. Equation (B.6) relates the real cost of labour (w minus the GDP deflator) to the real consumer wage (w minus the CPI) and the inverse of the TOT. Equation (B.7) relates the real cost of capital (v minus the GDP deflator) to the rate of return (v minus the investment price index) and the inverse of the TOT. Equation (B.9) relates the K/L ratio to the RCL/RCK ratio. Equation (B.10) makes investment a positive function of the rate of return on capital (*ROR*). The final equation determines the ration of private to public spending. To complete the description of the BOTE model we have to consider an appropriate closure for Equations (B.1) to (B.11). The closure in the very short-run is explained with the aid of the equations in column 1 in the BOTE model.

[8] The terms of trade (TOT) is defined as the ratio between the export price index and import price index. The export price index in turn is negatively related to the volume of exports.

Equations (B.1) to (B.11) comprise of 11 equations and 17 unknowns. A conventional standard short-run closure would have Y, X, C, M, TOT, RCL, ROR, L, RCK, I and Γ determined endogenously, given exogenous values for A, K, G, APC, V, W and FROR. With relatively high export demand elasticities and exogenous import prices, there is little scope for significant movements in the TOT. A convenient starting point then is to note that with little change in the TOT and with W exogenous, (B.6) can be identified with determining the RCL. With the RCL determined via (B.6) and A set exogenously, (B.9) determines the RCK. With RCL and RCK determined and K exogenous, (B.8) determines L. With L determined and K and A exogenous, (B.1) determines Y. With little change in the TOT and Y determined via (B.1), equation (B.3) and (B.4) determines C and M respectively. With C determined, equation (B.11) determines Γ. Again with little change in the TOT and the RCK determined via (B.9), equation (B.7) determines the ROR, which in turn determines investment (I) in (B.10). With Y, C, G, I and M explained, (B.2) determines X. With X thus determined, the TOT are determined by (B.5)

The description of UgAGE-D long-run behaviour differs in three respects from the short-run closure described above. First, in the long run we hold the ratio of public to private consumption exogenous. In our BOTE equations, this is represented by long-run exogeneity of Γ and endogeneity of G. These variables appear in (B.2), (B.3) and (B.11). Second, policy-case employment rates moves towards their employment trend levels via real wage adjustment. In BOTE, this is represented by long-run exogeneity of L and endogeneity of W. Thirdly, the short-run operation of (B.10) gradually drives the rate of return back to its baseline value via capital adjustment. In the BOTE model, the end-point of this process is represented by ROR exogenous and K endogenous. With ROR exogenous in the long run, (B.7) determines RCK and (B.8) determines K. With L tied down by (B.8) and the RCK determined by (B.7), (B.6) largely determines W.

6.1 Economic impacts of the newly discovered oil: construction phase

During the construction phase we are increasing investments in the *Raw oil* and *Petroleum* industries. The construction phase is between 2014 and 2016.

In the simulation setting of the construction phase, we are facing an upward sloping labour supply schedule (see section 4.3). The construction phase increases the demand for labour. We use equations (B.6) to (B.8) in Table 3, column 1 to aid our understanding of the increase in employment. In the short-run capital stocks are fixed, based on the assumption that there is not enough time for capital to accumulate. Wages are also assumed to be fixed in the short-run based on the assumption that wages are sticky. In the BOTE model this is evident by the exogenous status of K and W in column 1 of Table 3.

Given that labour demand increases and capital stock (K) is fixed in the short run, the construction phase raises the marginal product of capital, leading to an increase in capital rentals. Assuming just for the moment that there is little change in the TOT, an increase in the ROR increases the real cost of capital ((B.7) in BOTE). Also note that in the BOTE model with W exogenous there is little scope of change in the RCL. Given that capital stock is fixed, any increase (decrease) in aggregate employment (L) leads to a fall in the capital-labour ratio. The fall in the capital/labour ratio must be accompanied by (1) a decrease in real producer wage (RCL) relative to the rate of return on capital or (2) and increase in the real cost of capital (RCK) relative to the real cost of labour. This is confirmed in the BOTE equation (B.8).

Our results show that in the short-run employment increases by approximately 3 per cent. However, through the wage adjustment mechanism the increase in employment leads to an increase in real wages.[9]

[9] The wage adjustment mechanism shows that if employment in the policy simulation is higher than trend employment, wage will increase. We can write the percentage change in the average real wage as:
$w = \alpha * employ\_i$ (1.46 = 0.5*2.92).

Real wages rise (nominal wage deflated by the CPI) by 1.45 per cent, with employment increasing by 3 per cent. Our results further show that the producer real wage falls (-2.4 per cent) as the average price in capital rises. This implies that the RCL/RCK falls in line with the fall in the K/L ratio.

The consumer real wage increases at the same time as the real producer wage falls. This is because the GDP deflator increases more than CPI.[10] The reason for the sharp increase in the GDP deflator is because the price of an increase in construction is much larger than other commodities. Construction is an investment activity and appears in the GDP deflator and not CPI.

Our results suggest that gross national expenditure (GNE) exceeds GDP. This implies that the trade balance has to move towards a deficit. The mechanism by which this occurs is a real appreciation. In other words, the construction phase induces a real appreciation as the price of non-traded construction rises relative to other goods and services. Real aggregate consumption increases by 5.86 per cent and real investment by 13.1 per cent while real GDP increases only by 1.6 per cent.

6.2 The operational phase of the investment project: increase in exports

In modelling the operational phase of the project, we use UgAGE-D to simulate the impact of an increase in the exports of petroleum. We consider the long-run impact of the increase in exports of petroleum.

In the short-run we assume that capital stock is fixed and the ROR set endogenously. As the rates of return increases, investment increases leading to the accumulation in capital stock. Over time, the increase in capital stock causes the deviation in capital rentals to decline, allowing the rates of return to move back to their baseline level. We represent this long-run outcome of

[10] The percentage change in the GDP deflator is defined as

$$p0gdp = Scon * p3 + Sinv * p2 + Sgov * P5 + Sexp * p4 - Simp$$

Where *Scon* is the share of consumption in GDP. The other shares can be interpreted in a similar way. The CPI only includes p3.

this process via the exogenous status of the ROR and endogenous status of K (see Table 3, column 2). We assume that the labour market adjusts via the real wage adjustment mechanism. This means that the long run outcome of a positive shock to the economy will be realised as an increase in real wage while national employment remains unchanged. In the BOTE model we represent this outcome via the exogenous setting of the ROR and L, and the endogenous setting of K and W.

We can view the increase in petroleum exports as a positive shock to the TOT (equation (B.5) in the BOTE model). Given that the ROR are fixed, the positive deviation in the Ugandan TOT leads to a fall in the RCK (B.7). This implies that via (B.9) and (B.6) the real producer wage (RCL) and the consumer wage (W) should increase. Due to the changes in the RCK and RCL, capital stock increases. To expand on the causes of the positive deviation in capital stock we refer to equations (E.1) and (E.2) below.

Equilibrium in the capital market implies that the real cost of capital is equal to the marginal physical product of capital. This condition can be expressed in (E.1).

$$\frac{P_{cap}}{P_{gdp}} = \frac{1}{A} * \frac{\partial Y}{\partial K}\left(\frac{K}{L}\right) \qquad \text{(E.1)}$$

where
- P_{cap} is the rental price of a unit of capital and P_{gdp} is the cost of a unit of GDP;
- A is the technical change variable; and
- $\frac{\partial Y}{\partial K}$ is the partial derivative of Y with respect to K. We write $\frac{\partial Y}{\partial K}$ as a function of the $\frac{K}{L}$.

Equation (E.1) confirms that if there is no change in technology or the real cost of capital, in the long run we expect capital stock to increase by the same percentage as labour input as to keep the capital–labour ratio unchanged. However, during the policy simulation the real cost of capital does not stay at the baseline values. The main driver for the change in the RCK is the deviation in the TOT.[11] Our results show that capital stock is 11.9 per cent higher that the baseline. With productivity and employment exogenous, the increase in GDP (7.2 per cent) is explained by the increase in capital. Aggregate consumption increases due to the positive deviation in Y and the TOT. This explains why aggregate consumption increases by more than GDP. Our results suggest that in the long run consumption increases by 12.6 per cent.

The sharp increase in petroleum exports causes a real appreciation, which affects industries that mainly export their output. In terms of industry results, the worst affected industries are hotels and restaurants, fabricated metal products, textiles leather and footwear and basic metals – all traditionally exported commodities. Other sectors negatively impacted are the agricultural and other mining sectors. The main reason for the output deviation of these two sectors is their use of land. In UgAGE these sectors are the only users of land. As the economy expands, the output growth in these sectors is dampened because land is exogenous. Within the manufacturing sector, the deviation in output is the lowest for the Food sector. This is because agriculture output is mainly used as intermediate input into the production of food and because food has a low expenditure elasticity. Therefore, the negative output in the food sector follows the dampened agriculture output, that is, the capacity of the food-processing sector to expand is limited by agriculture's expansion prospects.

7. Conclusion

[11] The real cost of capital can be written as:

$$\frac{Pcap}{Pgdp} = \frac{Pcap}{Pinv} * \frac{Pinv}{Pgne} * \frac{Pgne}{Pgdp}$$

$RCK = ROR * \frac{Pinv}{Pgdp} * \frac{1}{TOT}$ which is very similar to (B.7) in the BOTE model.

There is an expectation that ordinary Ugandans would benefit from the discoveries of large amounts of oil in the form of improvements in their livelihoods as well as in quality of life. According to Aryeetey and Asmah (2011) the newly discovered natural resources and the associated windfalls are expected to be used to deliver substantial social, economic and infrastructure improvements in the country.

In this paper we use a detailed economy-wide model of Uganda to investigate the economy-wide effects of the extraction of newly discovered oil. We developed a dynamic model that allows capital to accumulate over time and the labour market to respond to changes in real wage. We also constructed a database that captures the features of the Ugandan economy.

We use the dynamic CGE model to simulate the effect of extracting natural resources. We do this via two different closures, each representing a specific phase in the extraction process. The first closure represents the construction phase. The results are explained within the context of a short-run setting where we assume that capital stocks are fixed, based on the assumption that there is not enough time for capital to accumulate. Wages are also assumed to be fixed in the short-run based on the assumption that wages are sticky. Given that labour demand increases and capital stock (K) is fixed in the short run, the construction phase raises the marginal product of capital, leading to an increase in real cost of capital relative to the cost of labour. This is consistent with the fall in the capital/labour ratio. Due to the large increase in investments, GNE exceeds GDP, implying that the trade balance moves towards deficit via an appreciation in the currency. In the operational phase we increase exports of petroleum which is viewed as a positive shock to the terms of trade. The sharp increase in petroleum exports causes a real appreciation, which affects industries that mainly export their output.

Our results are consistent with the Dutch Disease literature in that an exchange rate appreciation takes place when new resources are discovered and exported. Fielding and Gibson used a dynamic CGE model of Uganda and found, however, that this happens in the short run only. In the longer run the exchange rate recovers (Fielding & Gibson, 2011). We found the same result in our simulation where the terms of trade increases rapidly in the short run but stabilises just above its starting value. The second typical Dutch Disease result is that exports of tradable goods decrease. Our findings support this result. They show a sharp decrease in the exports of tradable goods. The decrease is sharp in the short run, and continues gradually in the long run.

In conclusion, we find similar results for Uganda that other CGE modellers have found for Uganda and other countries. We would therefore like to reiterate the advice given by Aryeetey and Asmah (2011) as well as Tuokuu (2012) that governments should spend the newly acquired revenues in such a way that non-resource export sectors are protected, while taking future generations into consideration. They should specifically emphasize investing in the long term accumulation of human and infrastructure capital, as well as technological innovation.

Although UgAGE-D contains a detailed representation of Uganda, scope exists to develop the model even further. Firstly, we hope to extend the model to include a measure of resource rents. It is important to capture the rents and to manage the large change in the terms of trade. Secondly, how would the government use these rents in Uganda to the benefit of its citizens? Would the government rather invest in education or in other investment projects such as the Kampala-Entebbe Expressway. One may argue that countries, such as Uganda, with low human development would benefit more when the government invests in programs that improve human development. These programs include education and health programs.

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Table 1. Summarised SAM for Uganda, 2009, billions of shillings

		1 Domestic Commodities	2 Imported commodities	3 Industries	4 Labour	5 Mixed income	6 Capital	7 Production Tax	8 Commodity Tax	9 Tariff	10 Households	11 Enterprises	12 Government	13 Private Investment	14 Stocks	15 Rest of the World	16 Total
		← C →	← C →	← I →	← O →		← 1 →	← 1 →	← 1 →	← 1 →	← 1 →	← 1 →	← 1 →	← 1 →	← 1 →	← 1 →	← 1 →
1 Domestic Commodities	C ↓			V1BAS("dom") + V1MAR("dom") (9,638)							V3BAS("dom") + V3MAR("dom") (19,844)		V5BAS("dom") + V5MAR("dom") (3,232)	V2BAS("dom") + V2MAR("dom") (5,163)	V6BAS("dom") (81)	V4BAS("dom") + V4MAR("dom") (7,787)	Demand for Domestic Commodities
2 Imported commodities	C ↓			V1BAS("imp") + V1MAR("imp") (4,624)							V3BAS("imp") + V3MAR("imp") (4,341)		V5BAS("imp") + V5MAR("imp") (49)	V2BAS("imp") + V2MAR("imp") (2,013)	V6BAS("imp") (11)		Demand for Imported Commodities
3 Industries	I ↓	MAKE (45,746)															Sales
4 Labour	O ↓			V1LAB_O (9,568)													Wage Income
5 Mixed income				(12,911)													Mixed Income
6 Capital	1 ↓			V1CAP + V1LND (7,583)													Capital Income
7 Production Tax	I ↓			V1PTX (1,093)													Production Tax
8 Commodity Tax	1 ↓			V1TAX_CSI (328)							V3TAX_CS (1,448)		V5TAX_CS (0)	V2TAX_CS (133)		V4TAX_C (0)	Commodity Tax
9 Tariff	C ↓		V0TAR (481,043)														Tariff
10 Households	1 ↓				V1LAB_I (9,568)	(12,911)					VHOUHOU (3,464)	VHOUENT (5,705)	VHOUGOV (200)			VHOUROW (1,900)	Household Income
11 Enterprises	1 ↓						V1CAP_I (7,583)				VENTHOU (40)	VENTENT (542)	VENTGOV (280)			VENTROW (358)	Enterprises' Income
12 Government	1 ↓							V1PTX_I (1,093)	VTAX_CSI (1,910)	V0TAR_C (481)	VGOVHOU (466)	VGOVENT (448)				VGOWROW (3,068)	Government Income
13 Private Investment	1 ↓										VSAVHOU (2,442)	VSAVENT (1,421)	VSAVGOV (3,544)			VSAVROW (-5)	Savings
14 Stocks	i ↓													VSTKINV_CS			Stocks
15 Rest of the World	C ↓		V0CIF (10,557,101)								VROWHOU (1,704)	VROWENT (686)	VROWGOV (160)				Foreign Exchange Receipts
16 Total	1 ↓	Supply of domestic Commodities	Supply of Imported Commodities	Output (Costs)	Wage Costs	Mixed i Costs	Cost of Capital	Production Tax	Commodity Tax	Tariff	Household Expenditures	Enterprises' Expenditure	Government Expenditure	Private Investment	Stocks	Foreign Exchange Payments	

Legend: I – 34 Industries; C – 34 Commodities; O – 16 Labour Class Types;
Note: Blue cells represent data based on 2002 SAM shares (i.e., not found in Figure 1).
Red cells are calculated as residuals

Table 2. Comparison between oil reserves and refinery capacity per day

	Country	Capacity of refinery in b/d	Amount of reserves in billions of barrels of oil
1.	Libya	220,000	48
2.	Nigeria	210,000	37
3.	Angola	56,000	13.5
4.	Algeria	335,000	13
5.	**Uganda**	**180,000**	**3.5**
6.	Ghana	45,000	5
7.	Kenya	70,000	none

Source: Matsiko, 2012.

Table 3. BOTE: stylised representation of the main relationships in UgAGE-D

Short-run closure	**"Effective" long run closure**	
Y = 1/**A***f1*(**K**,L)	Y = 1/**A***f1*(K,**L**)	B.1
Y = C + I + **G** + X - M	Y = C + I + G + X - M	B.2
C + **G** = **APC***Y**f2*(TOT)	C + G = **APC***Y**f2*(TOT)	B.3
M = *f3*(Y, TOT)	M = *f3*(Y, TOT)	B.4
TOT = *f4*(1/X, **V**)	TOT = *f4*(1/X, **V**)	B.5
RCL = W/Pgdp = **W*** *f5*(1/TOT)	RCL = W* *f5*(1/TOT)	B.6
RCK = Pk/Pgdp = ROR* *f6*(1/TOT)	RCK = **ROR*** *f6*(1/TOT)	B.7
K/L = *f7*(RCL/RCK)	K/**L** = *f7*(RCL/RCK)	B.8
RCL***A** = *f8*(1/(RCK***A**))	RCL***A** = *f8*(1/(RCK***A**))	B.9
I = *f9*(ROR, **FROR**)	I = *f9*(**ROR**, FROR)	B.10
C/**G** = Γ	C/G = **Γ**	B.11

Table 4. Construction phase - short-run results

	Variables	Percentage change
1.	Real GDP	1.61
2.	Real consumption (private)	5.86
3.	Real consumption (public)	5.86
4.	Real investment	13.15
5.	Exports	-13.51
6.	Imports	8.65
7.	Employment	2.92
8.	Capital	0.1
9.	GDP deflator	13.74
10.	Investment price index	17.59
11.	Consumer price index	9.78
12.	Nominal wage	11.34
13.	Consumer real wage	1.45
14.	Producer real wage	-2.4

Figure 1. Structure of the CGE database

			Absorption Matrix					
			1	2	3	4	5	6
			Producers	Investors	Household	Export	Government	Change in Inventories
		Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
1	Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
2	Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
3	Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
4	Labour	↑ OCC ↓	V1LAB					
5	Capital	↑ 1 ↓	V1CAP					
6	Land	↑ 1 ↓	V1LND					
7	Production Taxes	↑ 1 ↓	V1PTX					

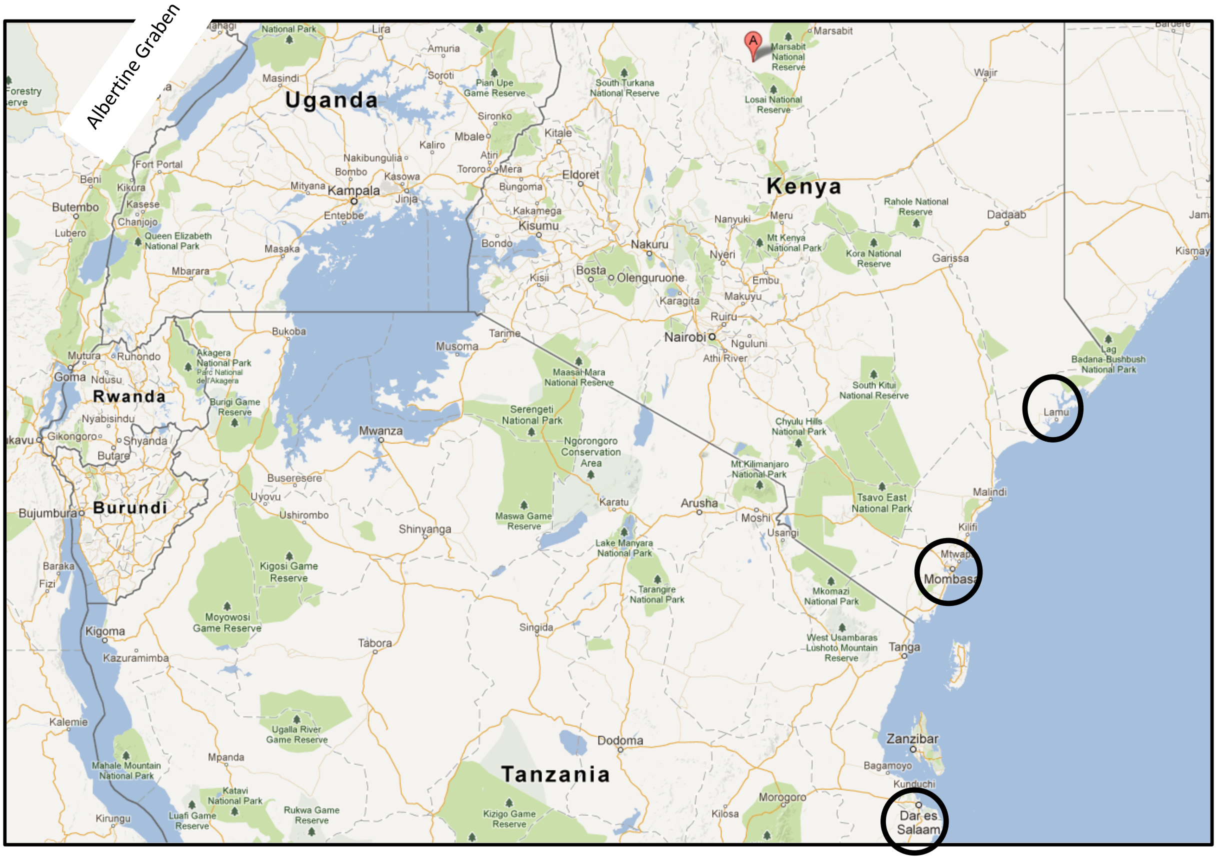
C = Number of commodities
I = Number of industries
S = Sources (domestic, imported)
OCC = Number of occupation types
M = Number of commodities used as margins

	Joint production matrix
Size	← I →
↑ C ↓	MAKE

	Tariffs
Size	← 1 →
↑ C ↓	V0TAR

Adapted from Horridge, 2006: 9.

Map 1a. Map of Uganda



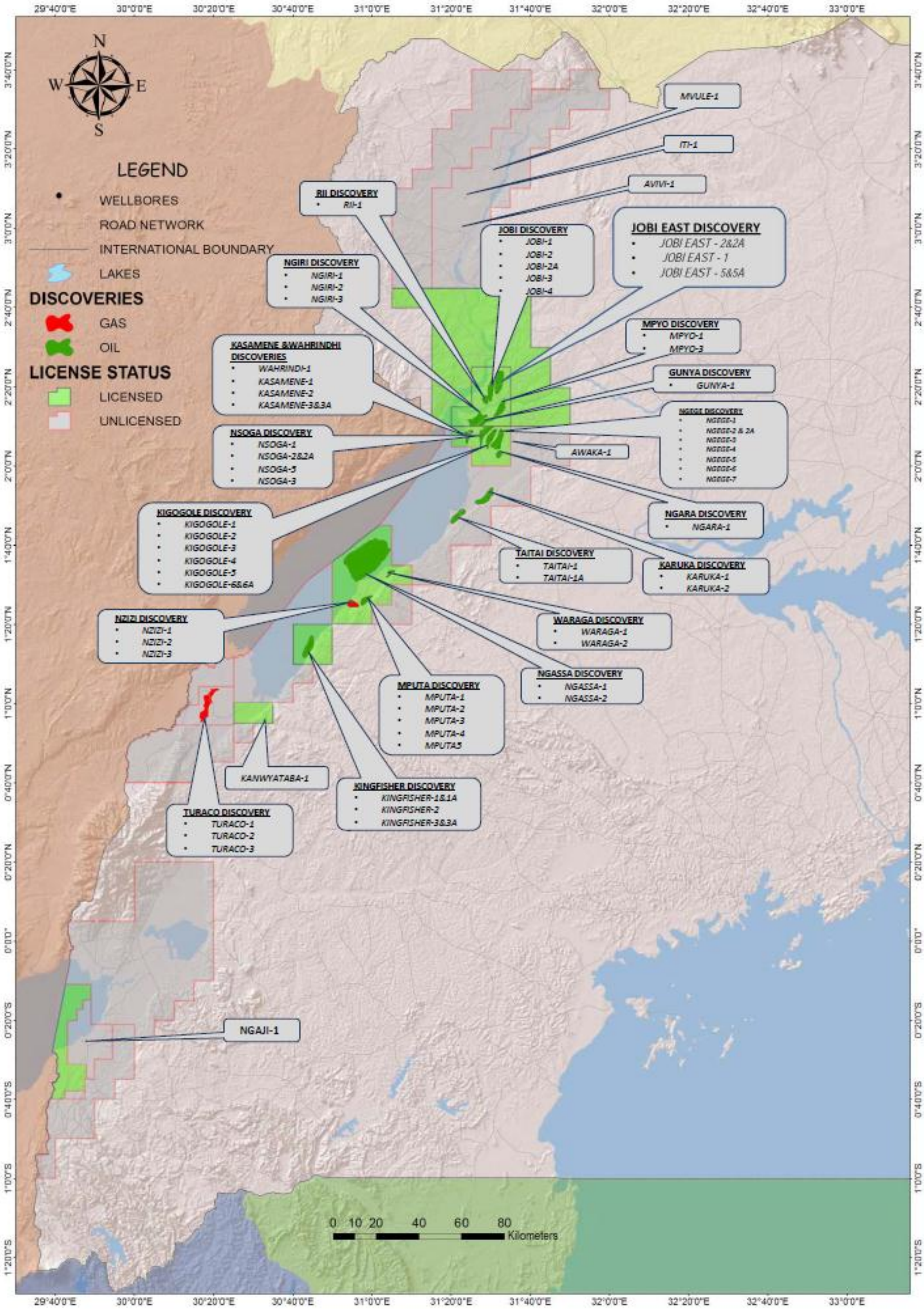
Source: Google maps

Map 1b. Potential for petroleum exploration

1. Albertine Graben
2. Hoima Basin
   Lake Kyoga Basin
   Kadam-Moroto Basin
3. Lake Wamala Basin
   Lake Victoria Basin

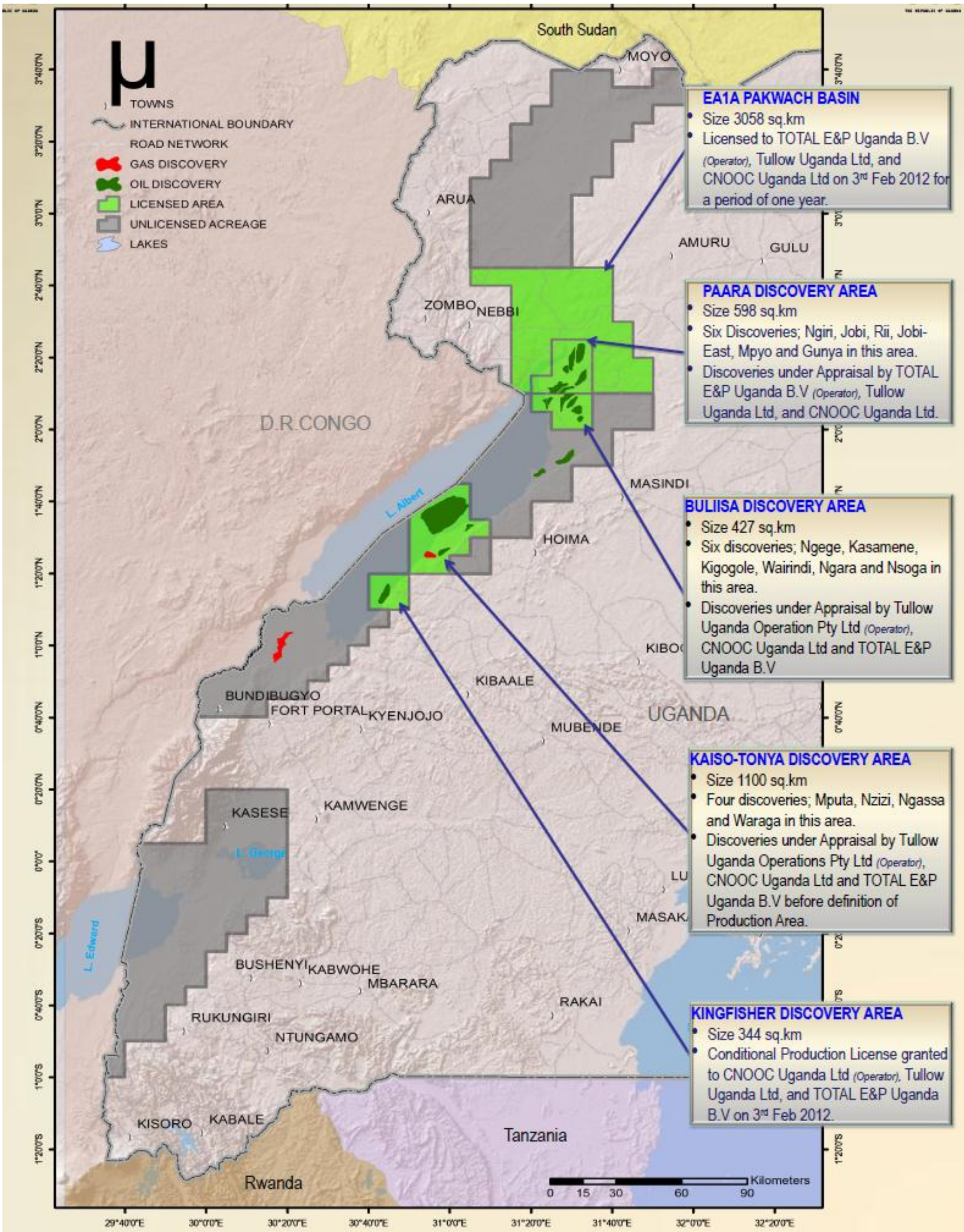
Source: Kabanda, 2012

Map 2. Wells drilled and discoveries in the Albertine Graben



Source: Petroleum Exploration and Production Department (http://www.petroleum.go.ug/publications.php)

Map 3. Status of licensing in the Albertine Graben of Uganda



Source: Petroleum Exploration and Production Department (http://www.petroleum.go.ug/publications.php)