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Impacts of Oil Discovery on Households in Uganda: A CGE Analysis

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ABSTRACT

This study analyses the impact of oil discovery on household poverty and inequality by employing a CGE model using 2007 SAM for Uganda. The oil production and export simulations show a decline in absolute poverty, poverty gaps and severity. Further, our findings showcase a positive effect of production and exports on household welfare, except for urban farm households. This study recommends for the managers of the economy to pay special attention towards injection of a reasonable portion of oil rent in sectors which positively contribute to the economy, diversify non-oil exports and above all, boost private consumption.

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1. Introduction

Uganda is a landlocked country located in East Africa. It is endowed with substantial natural resources, notably sufficient fertile land, fresh water bodies, regular rainfall, mineral deposits, diverse wild life and landscape (Kamugisha, 1993). In 2006, approximately 6.5 billion barrels of recoverable oil were discovered, whereas the estimated level of production for 2020 was set at 200,000 to 230,000 barrels a day (Musisi, 2018). The government is to receive revenue from the production share, exploration licenses, royalty, investment shares, capital gains and taxes on oil companies (Vokes, 2012). This revenue is earmarked for infrastructure development, and debt servicing. The discovery is expected to generate jobs and boost GDP by 7% to 10% (Vokes, 2012).

The experiences of resource-abundant countries however, point to an alarming prospect. Studies suggest that resource-abundant economies lag behind in terms of real GDP growth (Gelb, 1988; Sachs & Warner, 1995, 2001); that the negative relationship between resource abundance and economic growth is stronger for oil, minerals, and other point-source resources than for agriculture (Sala-i-Martin & Subramanian, 2013; Stevens, 2003). Nonetheless, several countries have managed to avoid this so-called "resource curse". Indonesia's economy grew by an average of 4 percent per year during 1965–90, despite high oil and gas exports (Bevan, Collier, & Gunning, 1999). Botswana grew at double-digit in the 1970s and 1980s due to rapid growth of diamond exports (Acemoglu, Johnson, & Robinson, 2002). Similarly, Malaysia, Australia, and Norway, have successfully used resources to diversify their economies. Nevertheless, the impacts of natural resources discovery on the economy rests on the absorptive and managerial capacity of the government to manage large-scale investment programs from the windfall (Easterly, Islam, & Stiglitz, 2001; Ross, 2001). The massive exports surges inflow of foreign exchange

thereby appreciating the real exchange rate rendering tradable such as agriculture uncompetitive (Rodrick, 2003).

A vast literature on oil exploitation examines primarily its impacts on the environment. For instance, Ikelegbe (2005) found pollution of land, water, flora and fauna on a massive scale which destroyed the local economy in terms of increased unemployment, crop failures and diseases. These findings are consistent with Davies and Kingston (1992) and O'Rourke and Connolly (2003). Other studies on oil extraction focus on production peaks, their impacts and mitigations. For example, Hirsch, Bezdek, and Wendling (2005) and Holland (2008) found increasing prices of oil and volatility to have negative economic, political and social consequences.

Studies on the impact of oil export mainly focus on economic performance. For instance, Looney (1984) concluded that oil exports rapidly improved terms of trade, national income, balance of payments, fiscal budget and economy. Similarly, Heidarian and Green (1989), Karamelikli, Akalin, and Arslan (2017), Parvin Hosseini and Tang (2014), Adedokun (2012) and Junior (2015) found positive impact of oil exports on the economy. However, Peter (2010) found negative and insignificant impacts of oil export on Nigeria.

This study contributes to the existing literature on oil impacts as follows: methodologically, we employ CGE modeling, which can capture the impact economy-wide. The findings provide an added input on oil policy formulation. Finally, it highlights the impact of oil discovery in Uganda on country's core challenges of poverty, inequality and welfare.

2. The Computable General Equilibrium Model

We use a static CGE model as suggested by Lofgren et al. (2002) to capture the inter-sectoral impacts of shocks. The model has five households1; three household endowments2, three types of labor3, production functions4, taxes and variables5. It is structured based on 3 blocks; price, production and trade, and institution and constraints. The price block links variables, while the production block shows how intermediate factors are combined using Cobb Douglas and Leontief functions. It also shows how profits are maximized. The institutions block describes the earnings, expenditures and savings of the agents. Households earn from labor, capital and land; and spend on commodities, taxes, and savings. Firms' earnings from capital are spent on households. The government receives taxes and income from rest of the world; and spends on commodities, public service and savings. The constraints block describes how factor supply must equal factor demand, commodity supply must equal commodity demand, foreign earnings must equal foreign spending and savings must equal investment. The study uses the 2007 SAM developed by Thurlow (2008). Armington elasticities are obtained from Olarreaga et al. (2004) and population from the Statistical Abstract 2013 (UBOS, 2013).

2.1 Poverty Indices

We use the Foster-Greer-Thorbecke (FGT) index to measure poverty (Haughton & Khandker, 2009). FGT indices (P_α), are described as

$$P_\alpha = \frac{1}{Nz^\alpha}\sum_{j=1}^{J}\left(z - YH_j\right)^\alpha \qquad (1)$$

where, *N* is the total population of households in the sample, *j* is the population of poor households, *z* is the poverty line, YH_j is the income of household j, and α is the parameter that distinguishes between the different indices of FGT. When α is 0, we have the head count ratio, a measure of the incidences of poverty. While α=1 depicts poverty gap- a measure of poverty depth and α=2 depicts poverty severity.

2.2 Inequality Indices

We employ the generalized entropy index to measure inequality as described by Haughton and Khandker (2009). Theil indices ranges from 0 (lowest inequality) to *In N* (highest inequality). Arithmetically, the indices are written as:

Theil T (TT)

1 Rural-farm, rural non-farm, Kampala non-farm, Urban-farm, Urban non-farm
2 Labor, capital and land
3 Self-employed, skilled and unskilled
4 Constant elasticity of substitution and transformation
5 Endogenous and exogenous

$$TT = In\left(\frac{\sum_h N_h}{\sum_h YH_h}\right) - \frac{\sum_h YH_h In\left(\frac{\sum_h N_h}{\sum_h YH_h}\right)}{\sum_h YH_h} \quad (2)$$

Where, *YH* is subgroup Income, ∑*YH* is total population income, *N* is subgroup population, ∑*N* is total population, *h* is household.

Theil L (TL)

$$TL = In\left(\frac{\sum_h YH_h}{\sum_h N_h}\right) - \frac{\sum_h N_h In\left(\frac{\sum_h YH_h}{\sum_h N_h}\right)}{\sum_h N_h} \quad (3)$$

"Symmetrized" Theil index can be calculated as: $TS = \frac{1}{2}(TT - TL)$

Putting values of TT and TL in the above equation

$$TS = \frac{1}{2}\sum_h In\left(\frac{YH_h}{N_h}\right)\left(\frac{YH_h}{\sum_h YH_h} - \frac{N_h}{\sum_h N_h}\right) \quad (4)$$

Hoover's Index (HI)

$$HI = \frac{1}{2}\sum_h \left|\frac{YH_h}{\sum_h YH_h} - \frac{N_h}{\sum_h N_h}\right| \quad (5)$$

2.3 Welfare Measures

We use Equivalent Variations (EV) and Compensating Variations to measure welfare (CV) (Hicks (1939). EV measures changes in wealth resulting from changes in prices, given that income remains constant and assesses the winner-loser concern when an economic policy is carried out. Further, it measures changes in the value of money resulting from price change. Described as

$$EV_h = \left(\frac{CPIH_h^0}{CPIH_h^1}\right) EH_h^1 - EH_h^0 \quad (6)$$

Where, $CPIH_h^0$ is base year consumer price index of household (h), $CPIH_h^1$ is shocked consumer price index of household (h), EH_h^0 is base year consumption expenditure of household (h), EH_h^1 is shocked consumption expenditure of household (h). CV, measures changes in utility due to price changes. It denotes the additional money a household would require reaching the initial utility after a change in prices, product quality, product launch or discovery. It finds the effect of price change on household welfare. Stated as

$$CV_h = \frac{\left(EH_h^1 - CPIH_h^1\right)}{\left(CPIH_h^0\right)\left(EH_h^0\right)} \quad (7)$$

Further, we look at the economy wide EV (TEV) which is arithmetically written as

$$TEV = 100\left(\frac{\sum_h EV_h}{\sum_h EH_h^0}\right) \quad (8)$$

Similarly, the economy wide CV (TCV) is described as

$$TCV = 100\left(\frac{CV_h}{EH_h^0}\right) \quad (9)$$

2.4 Macroeconomic Closures

In the model, markets and accounts are cleared as follows: foreign saving is fixed enabling a flexible exchange rate to clear current account. Savings are fixed too, enabling investment to adjust investment-saving account. The price of capital is also fixed, and factor price distortion adjusts to clear capital market. Labor is fully employed, and wages adjust to clear the labor market.

3. Simulation Results, Presentation and Discussion

The simulation designs are presented in Table 1. A shock of 550% is performed on both oil production and export. A large shock as such is required given the small proportion of oil in the 2007 SAM for Uganda.

Table 1: Simulation Scenarios

Simulation	Base Scenario	Share in SAM	Forecasted New Shares
Simulation 1	Production	3.83%	3.83% x550% = 21.1%
Simulation 2	Export	7.70%	7.70% x 550% = 42.4%

In simulation 1, a shock on the production of oil is performed, which is only 3.83% of the total production as reported in 2007 SAM for Uganda. A shock of 550% raises the level of oil production to 21.1%, which portrays the picture in most resource-abundant economies. In second simulation a shock on oil exports is performed, which is 7.7% of the total exports. Hence, an increase of 550% elevates it to 42.35% of total exports. This represents the real trend in poor oil rich nations, where oil accounts for the bulk of total exports. The results of these shocks are presented in Tables 2 through 6.

3.1. Impact on Household Income

The results of income for various types of households are presented in Table 2. Except for rural farm households, where income increased from Sh. 10,400,000.00 to Sh. 10,718,240.00, other households have their incomes declining across all simulations. In simulation 1, income of rural farm households increases due to a surge in agriculture and diversity of its earnings. While, the decline in incomes of other households may be due to relative shares in declining sectors6. In terms of simulation 2, the results show how exports increased rural incomes via increase in agricultural exports and general economic improvements, as suggested by Murshed (1997).

Table 2: Impact on Household Income

	Base	Simulation 1	Simulation 2
HHD-R-F	10,400,000.00	10,718,240.00	10,822,448.00
HHD-R-NF	2,869,675.84	115,647.94	87,008.57
HHD-K-NF	3,666,723.61	151,435.69	122,175.23
HHD-U-F	1,570,701.05	69,424.99	53,749.39
HHD-U-NF	1,967,955.47	85,409.27	65,769.07
Note: HHD-R-F is rural farm households, HHD-R-NF is rural nonfarm households, HHD-K-NF is Kampala nonfarm households, HHD-U-F is urban farm households and HHD-U-NF is urban nonfarm households			

3.2. Impact on Household Poverty

The impact of oil on various sectors, macroeconomic variables and households have greater bearing on both poverty and inequality. This is so because of their impact on household income and expenditure patterns. The estimated impact of oil discovery on household poverty is presented in Table 3. In simulation 1, oil production reduces absolute poverty (P0: 31.43% to 28.91%), poverty gap (P1: 14.43% to 13.28%) and poverty severity (P2: 6.78% to 6.24%). Similarly, in simulation 2, oil export decreases absolute poverty (P0: 31.43% to 26.71%), poverty

6 The results of simulations on various sectors and macroeconomic variables can be obtained from authors on personal request.

gap (P1: 14.43% to 12.27%) and poverty severity (P2: 6.78% to 5.76%). The reductions in poverty is due to improvements in sectors, macro economy and incomes. This result is consistent with Idemudia (2009) study on oil and poverty in Nigeria.

Table 3: Impact on Household Poverty

	Base	Simulation 1	Simulation 2
P0	0.31426	0.2891192	0.267121
P1	0.144329	0.13278268	0.12267965
P2	0.067801	0.06237692	0.05763085
Note: P0 is absolute poverty, P1 is poverty gap, and P2 is poverty severity.			

3.3. Impact on Household Income Inequality

The results of our simulations on income inequality are presented in Table 4. In simulation 1, there is a decline in income inequality; GINI (0.340863 to 0.31359396), Theil L (0.276654 to 0.25452168), Theil T (0.232254 to 0.21367368), Theil S (0.21684 to 0.1994928) and Hoover index (0.247102 to 0.22733384), and improvements in household welfare; TL (Sh.471,251.501 to Sh.508,951.6211), HI (Sh.453,745.487 to Sh.490,045.126) and TT (1.41E-06 to 1.52122E-06).

Table 4: Impact on inequality

Indexes	Base	Simulation 1	Simulation 2
Gini	0.340863	0.31359396	0.289734
Theil L	0.276654	0.25452168	0.235156
Theil T	0.232254	0.21367368	0.197416
Theil S	0.21684	0.1994928	0.184314
Hoover's Index	0.247102	0.22733384	0.210037
Welfare using TL	471251.5	508951.6211	541939.2
Welfare using HI	453745.5	490045.126	521807.3
Welfare using TT	1.41E-06	1.52122E-06	1.62E-06

The above results are contrary to the findings of Karl (1999), Stilwell (2009) and Yates (2009). They argue that oil booms tend to produce poverty, inequality and political crises. Similarly, in simulation 2, inequality declines, and welfare rises. The decline in inequality and rise in welfare is due to the surge in economic sectors, notably agriculture sector. The results are consistent with the study of Moradi (2009) on oil and inequality in Iran.

3.4. Impact on Household Welfare

Table 5 presents the equivalent variations, portraying individual welfare of households. Apart from urban farm households, all simulations have a positive effect on welfare; which is consistent with Caselli and Michaels (2013). According to equivalent variation, simulation 1 suggests that to keep welfare at its earlier level, the households whose welfare improved should give up their income resulting from this rise. Hence, rural farm should give up Sh.18864.10, rural nonfarm Sh.282.18, Kampala nonfarm Sh.489.14 and urban nonfarm Sh.143.49. Contrarily, urban farm households are affected by price fall, thus they should be offered Sh. 68,961.92 to retain their welfare. In simulation 2, households with positive values of EV should give away the respective amounts to maintain their welfare and urban farm households should be extended an equivalent amount to retain their welfare.

Table 5: Equivalent Variation of Households

	Simulation 1	Simulation 2
HHD-R-F	18,864.10	86,579.58
HHD-R-NF	282.18	261.03
HHD-K-NF	489.14	488.70
HHD-U-F	- 68,961.92	-53,534.39
HHD-U-NF	143.49	110.49
Note: HHD-R-F is rural farm households, HHD-R-NF is rural nonfarm households, HHD-K-NF is Kampala nonfarm households, HHD-U-F is urban farm households and HHD-U-NF is urban nonfarm households.		

The CV index in Table 6 suggests that in simulation 1; Sh.29,582.34, Sh.397.83, Sh.640.57 and Sh.228.90 compensate rural farm, rural nonfarm, Kampala nonfarm and urban nonfarm households respectively for the rise in prices to enjoy the same welfare as before. Conversely, urban farm households should give up Sh.68,892.50 to remain at the same welfare as before the decline in price. Similarly, according to simulation 2; HHD-R-F, HHD-R-NF, HHD-K-NF, and HHD-U-NF should be given the amount in Table 6 as compensation for the price rise effect, in order for them to enjoy the same welfare as before the price increase; while HHD-U-F should part with the amount in Table 8 to click back to the original welfare. Taking the economy as a whole, the values of EV and CV are depicted in Table 9.

Table 6: Compensating Variation of Households

	Simulation 1	Simulation 2
HHD-R-F	29,582.34	97,402.03
HHD-R-NF	397.83	348.03
HHD-K-NF	640.57	610.88
HHD-U-F	-68,892.50	- 53,480.64
HHD-U-NF	228.90	176.26
Note: As for Table 5.		

Table 7 shows that, individuals in the country are better off in simulation 1, while opposite in Simulation 2. For example, with respect to TEV in Simulation 1, it is implied that individuals are better off and so must be given Sh. 9836.60 to bring them to the initial welfare. In Simulation 2, individuals are worse off and therefore an amount of Sh. 6781.08 must be taken away from them to maintain the original welfare. Regarding TCV in Simulation 1, individuals are required to give up Sh.7608.57 because they are better off than before, while in Simulation 2, they should be given Sh.9011.31 because they are worse off than before.

Table 7: Economy-wide Equivalent and Compensating Variations

	Simulation 1	Simulation 2
TEV	-9836.6	6781.082
TCV	-7608.57	9011.312
Note: TEV is Economy-wide Equivalent Variation, TCV is Economy-wide Compensating Variation.		

5. Sensitivity Analysis

We perform sensitivity experiments before the conclusion on results to ascertain their robustness which has been accomplished by changing the values of elasticities as shown in Table 8. We find the effect of changes in elasticities close to zero, leading us to conclude that the results are appropriate for use in our model (see Tables A1 and A2, Appendix A).

Table 8: Simulation Parameters for Sensitivity Analysis

Experiment	Change in Elasticity
SA0	Original Armington and CET elasticities
SA1	50% rise in Armington elasticity
SA2	50% rise in CET elasticity
SA3	50% reduction in Armington elasticity
SA4	50% reduction in CET elasticity
SA5	50% rise in Armington and CET elasticity
SA6	50% reduction in Armington and CET elasticity
SA7	50% rise in Armington and 50% reduction in CET elasticity
SA8	50% reduction in Armington and 50% rise in CET elasticity
Note: SA is 'sensitivity analysis'. CET is 'constant elasticity of transformation'.	

6. Conclusions and Recommendations

The findings of this study show that oil production and exports reduce absolute poverty, severity and vulnerability. The obvious cause for such results is discovery having a spillover effects on the incomes of rural households, who account for the largest percentage of poor worker-force. A surge in the production of oil reduces household

inequality, as measured by the Gini coefficient and other entropy measures; while improving the household welfare. The results show that the poor can participate in the oil production process, though skilled labor and enormous investment are required for it; thus, leading to reduced inequality. On the other hand, oil exports equally reduce and enhance income inequality and welfare respectively. This is basically due to an increase in consumption of oil, which is a component of absorption inequality, as measured by mean expenditure. Further, the income derived from oil absorption and export increase household consumption in terms of imports, which may lead to an increase in overall expenditures. Therefore, since inequality in the model was computed using household expenditure, an increase in expenditure on domestic and import products mirrored a reduction of inequality in the simulations. Obviously, with a reduction in inequality and poverty, welfare must equally improve as shown in the results.

Overall, we look at three major stakeholders: the government, households and the international community. To have a significant impact on poverty and inequality, the government should promote investment in sectors that surge because of oil boom such as agriculture, industry, health and education; while some resources must be allocated to manufacturing and services to turn around their plight resulting from the boom to create jobs and expand opportunities. The households, while making their investments, must diversify and improve on the volume and quality of their exports, cut consumption to boost private investment to escape from the menace of poverty and inequality. Finally, the global community may share their expertise and experiences in oil policy formulation, managing Dutch disease, and natural resource curse for this new wealth to benefit the country, particularly the poor masses.

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Appendix A. Sensitivity Analysis Results

Table A1. Effects of Sensitivity Experiments on National Income Accounts (% change from base)

	SA0	SA1	SA2	SA3	SA4	SA5	SA6	SA7	SA8
GDPFC	-1.92E-09	-1.31E-09	-1.98E-09	-1.06E-09	-1.21E-09	-1.40E-09	-2.15E-10	-1.57E-09	-1.10E-09
GDPMP1	9.10E-14	2.78E-10	4.97E-11	4.36E-10	8.04E-11	1.56E-10	6.81E-10	1.40E-10	5.90E-10
GDPMP2	-1.74E-09	-1.30E-09	-1.81E-09	-8.59E-10	-1.05E-09	-1.39E-09	-2.83E-11	-1.40E-09	-1.07E-09
INVEST.	-1.58E-08	-6.09E-09	-1.46E-08	-1.27E-08	-1.38E-08	-6.26E-09	-1.24E-08	-1.67E-08	-2.21E-09
EXPORT	2.92E-10	2.80E-10	7.12E-10	-4.59E-10	-4.25E-10	5.17E-10	-9.79E-10	-1.95E-10	-1.70E-10
IMPORT	7.31E-04	6.97E-04	6.81E-04	4.25E-04	5.36E-04	6.84E-04	3.51E-04	7.17E-04	5.22E-04
NITAX	-1.53E-10	-1.27E-09	-2.83E-10	9.50E-10	3.78E-10	-1.30E-09	1.63E-09	1.58E-10	-7.53E-10
PRVCON	4.03E-09	-3.38E-10	3.55E-09	4.44E-09	4.35E-09	-3.59E-10	5.07E-09	4.64E-09	-9.85E-10

Table A2. Effects of Sensitivity Experiments on Household Income (% change from base)

	SA0	SA1	SA2	SA3	SA4	SA5	SA6	SA7	SA8
HHD-R-F	3.06E-10	-2.67E-10	2.13E-10	5.68E-10	4.52E-10	-2.81E-10	8.15E-10	4.69E-10	-3.05E-10
HHD-R-NF	-4.03E-10	-3.71E-10	-4.32E-10	-1.62E-10	-1.98E-10	-3.97E-10	8.23E-11	-2.90E-10	-3.37E-10
HHD-K-NF	-4.13E-10	-3.80E-10	-4.43E-10	-1.66E-10	-2.04E-10	-4.07E-10	8.39E-11	-2.97E-10	-3.46E-10
HHD-U-F	-4.42E-10	-5.64E-10	-5.07E-10	-5.78E-11	-1.25E-10	-6.03E-10	3.44E-10	-2.42E-10	-5.37E-10
HHD-U-NF	-4.34E-10	-4.03E-10	-4.66E-10	-1.74E-10	-2.12E-10	-4.31E-10	9.26E-11	-3.11E-10	-3.67E-10