International Journal of Economics and Finance; Vol. 6, No. 4; 2014
ISSN 1916-971X E-ISSN 1916-9728
Published by Canadian Center of Science and Education

Uranium Sales and Economic Well-Being in Niger: Is there "Dutch Disease"?

Issoufou Soumaila[1]

[1] Division of Research, Central Bank of Western African States, Dakar, Senegal

Correspondence: Issoufou Soumaila, Division of Research, Central Bank of Western African States, BCEAO-Head Office, P. O. BOX 3108, Dakar, Senegal. Tel: 221-78-145-8921. E-mail: isoumaila@gmail.com

Received: January 7, 2014 Accepted: January 23, 2014 Online Published: March 25, 2014
doi:10.5539/ijef.v6n4p88 URL: http://dx.doi.org/10.5539/ijef.v6n4p88

Abstract

After the uranium boom of 1970–1980's, Niger is experiencing a second round of a natural resources boom. Policy makers and civil societies are concerned about the impact of the resulting inflow of capital on macroeconomic variables and welfare. Recent studies have shown that countries with natural resources windfall as the main source of foreign exchange tend to grow more slowly than countries with exports led by manufactured goods. This is referred as the "Dutch Disease" problem. This study develops a dynamic general equilibrium model and utilizes it to quantify the effect of a uranium windfall on Niger's economy. The result of the simulations shows that the uranium windfall improves household welfare and is growth promoting. However, income inequality increases and inflation rises. The policy implication of the study is that "Dutch Disease" can be avoided by spending the windfall strategically.

Keywords: Niger, natural resources revenue, dutch disease, CGE modeling

1. Introduction

Niger is a land-locked, arid country situated in West-Africa. With an estimated 17 million population, it is almost twice the size of Texas in terms of land. Around 90% of the population lives in the southern part of the country, within 150 miles of the Nigerian border where the weather is favorable for agriculture. Eighty-one percent of Nigeriens live in rural area. Niger has the highest population growth rate in the world (3% per year) and 49% of the population is less the 15 years old. Agriculture is the most important sector of the economy (45 % of GDP) and is mostly practiced in the southern part of the country. The agricultural sector employs 80% of the population. The sector has low productivity and is vulnerable to climate variability due to recurrent droughts (1968–1974, 1983 and 2004). In 2004, a drought combined with locust invasion had devastating effects on rural households. Droughts also had devastating effects on livestock, another important sector of the Niger economy. During the 1984 drought, more than 50% of the cattle died, reducing household wealth. As in most developing countries and especially in Niger, livestock is seen as a form of investment. According to a United Nation Development Report, Niger has the lowest human development index in the world, mainly due to a very low combined primary, secondary and tertiary gross enrollment ratio; and more than 60% of the population lives on less than one dollar a day.

Nevertheless, Niger has tremendous reserves of natural resources, namely uranium, oil, natural gas, and gold. Gold was produced using rudimentary technology until 2004, when industrial production of gold started. In 2012, Niger produced it first barrel of oil with the exploitation of *Agadem* oil reserve. However, uranium is by far the most import natural resource in the country. In fact, Niger is currently the world's fourth-largest producer of uranium and with the production of Immouraren mine set to begin in 2016, the country could well be the first producer of yellow cake worldwide.

A likely increase in the quantity of uranium exported combined with the production of crude oil are seen by many observers as an opportunity for growth and prosperity in Niger. However, some recent studies have found a negative correlation between growth and a natural resource boom. Sachs and Warner (1999) among others found that resource booms seem to have done little to generate long-term growth, and may in fact have hindered growth on average. For example Congo and Nigeria, two natural resource abundant countries, experienced little or no growth over 40 years. Ross (2001) found that natural resources are strongly associated with unusually bad conditions for the poor. Gylfason (2007) distinguished five channels through which a boom in natural resources can negatively affect an economy: corruption, neglect of education, reduction of private and public investment, crowding out of financial capital, and reduced competitiveness. The reduction in competitiveness is primarily due to a phenomenon called Dutch Disease.

Although, there are many channels through which natural resources negatively affect the economy, the Dutch Disease channel has received more attention in the literature. Originally, the term "Dutch disease" referred to the negative effect of a booming sector on the non-booming sectors through an appreciation of the real exchange rate (RER). Corden and Neary (1982) were among the first researchers to study the effect of a booming sector on the other sectors in an economy. They distinguished two effects of a booming sector: The resource movement effect and the spending effect. They argue that the boom in the energy sector raises the marginal products of the mobile factors employed there and so draws resources out of other sectors, giving rise to various adjustments in the rest of the economy. They called this kind of effect the resource movement effect. The spending effect occurs when the booming sector raises real income in an economy, which increases spending on services like leisure, causing real exchange rate appreciation. Benjamin et al. (1989) argued that developing countries are more likely to suffer from the spending effect because capital and labor in the mining sector are primarily foreign. However, in Niger, labor is primarily domestic in the mining sector, although capital is foreign. Even though labor is domestic, the uranium sector is less likely to draw labor from the manufacturing sector. Indeed the mining sector in Niger is an unskilled labor intensive whereas the manufacturing sector tends to be skilled labor intensive. For the reason mentioned above, the present study will only focus on the spending effect.

Other papers have approach the Dutch disease issue in the context of learning by doing (LBD). Most of the literature on LBD and Dutch disease assumes that LBD is only specific to the tradeable manufacturing sector (Wijnbergen, 1984; Krugman, 1987; Sachs & Warner, 1999). The idea is that an inflow of windfall (Note 1) resource tends to appreciate the real exchange rate. The appreciation of the real exchange rate lessens the manufacturing sector, which is a source of productivity growth due to LBD. The net effect will be a growth disaster for the economy receiving the windfall. Gylfason et al. (1997) extended the literature and showed that a boom in the primary sector not only harms the high-skill secondary sector through an appreciation of real exchange rate but also generates real exchange uncertainty. Sachs and Warner (1995) argued that if neoclassical, competitive conditions prevail in the economy, then there will be nothing harmful about the shrinkage of the manufacturing sector. But if, however, the manufacturing sector is characterized by externalities in production, then the shrinkages the manufacturing sector caused by resource abundance can lead to a socially inefficient decline in growth.

Unlike most papers on LBD and Dutch disease, Torvik (2001) assumed that both tradeable and non-tradeable sectors experience LBD and that there is a learning spillover across the two sectors. He concluded that when faced with such a model, the real exchange rate depreciates in the long-run. In contrast to most literature, he found that production and productivity in both sectors may go up or down depending on the characteristic of the economy. Torvik (2005) further elaborated on the effect of Dutch Disease on the economy. He found that some Dutch Disease is always optimal and that lower growth in resource-abundant countries may not be a problem in itself, but may be part of an optimal growth path.

The present study differs from the previous literature in two ways. First, a dynamic computable general equilibrium is used to quantity the effect of the inflow of capital. Second, past studies only focused on the macroeconomic impact of the windfall whereas this study, in addition to macroeconomic impact, looks at the distributional and welfare impact of a natural resource windfall. To this end, the main objective of the paper is to build a CGE model for Niger's economy and use the model to test the Dutch disease hypothesis.

The rest of the paper is divided as follows. A detailed description of the model is presented in section 2. The simulation results are presented in section 3. Section 4 concludes the study with some policy implications.

2. The Model

CGE models incorporate the fundamental general equilibrium links among production structure, incomes of various groups, and patterns of demand (Dervis, Melo, & Robinson, 1982, p. 133). Although there are many models that are built for policy analysis (Econometric models, Input-output models, Linear programming models), CGE models have some key attractive features that make them very popular. For example, econometric models require long time series data. However, in developing countries like Niger, long time series data are not available. Moreover, econometric studies are biased more toward partial equilibrium than general equilibrium. Indeed, partial equilibrium models look at only the impact of economic policy on one market in an economy, thereby ignoring the interdependence among markets. As for input-output models, Partridge and Rickman (2010) note that they lack an explicit economic structure, which makes them unattractive for policy use. Dervis et al.

(1982) noted that both input-output models and linear programming models fail to incorporate a situation where economic agents independently maximize their own welfare and policy makers can only affect economic agent decisions indirectly. The following section presents the features of a recursive dynamic computable general equilibrium model (CGE) for Niger and the data used to calibrate the model.

2.1 Social Accounting Matrix of Niger

A social accounting matrix (SAM) provides the most important data to calibrate CGE models. A SAM represents a snap shot of an economy during a particular period, usually a year. It incorporates the input-output framework of inter-industry relationships and the "income equals expenditures" identities of the national income accounts. That is, data on production, consumption, investment, and trade and income distribution are presented in such way that the SAM replicates the circular flow of income and expenditures in a given year.

A 2004 SAM for Niger obtained from the National Institute of Statistics is used for this study. The SAM, prepared by the World Bank, combines the latest data on input-output data, household survey data, and other economic data. The SAM project was financed by the Belgium government under the Belgium Poverty Reduction Partnership (BPRP).

Table 1. Basic structure of Niger SAM (2004)

	Activities	Commodities	Factors	Household	Government	Direct Tax
Activities		Marketed Output		Home-Consumed Outputs		
Commodities	Intermediate Input			Private Consumption	Government Consumption	
Factors	Value-Added					
Household			Factor Income to Household		Transfers to Household	
Government						Direct Taxes
Direct Tax				Transfer to Government		
Production Tax	Value Added Tax					
Import Tax		Tariffs				
Export Tax		Export Taxes				
Other Tax		Other Taxes				
Saving				Household Savings	Government Savings	
ROW		Imports	Wages to ROW		Government Transfer to ROW	
Total	Activity Expenditure	Supply	Factor Expenditures	Household Expenditures	Government Expenditure	

Table 1. Continued

	Production Tax	Import Tax	Export Tax	Other Tax	Investment	ROW	Total
Activities							Activities Income
Commodities					Investment	Export	Demand
Factors							Factor Income
Household						Remittance	Household Income
Government	Production Taxes	Import Taxes	Export Taxes	Other taxes		Remittance	Government Income
Direct Tax							
Production Tax							
Import Tax							
Export Tax							
Other Tax							

Saving		Foreign Savings	Total Savings
ROW			Foreign Exchange Outflow
Total	Total Investment	Foreign Exchange Inflow	

Table 1 shows the structure of Niger's SAM. The SAM distinguishes between the commodities accounts and the activities accounts. The activities accounts include the entities that carry out production. The marketed output and home-consumed output sum to "activities income", which is priced at producer prices. The commodities accounts include final goods which can be consumed locally by households, business, and government or exported to the rest of the world.

There are nine activities and commodities in the SAM: rural, mining, manufacturing, utilities, construction, commerce, transport and telecommunication, financial services, and other services. The rural sector incorporates agriculture, livestock, fishery, and forestry activities. The manufacturing sector includes food and beverage industries, textiles industries, chemical and metal industries, and other manufacturing activities. The commerce sector is composed of privately owned enterprises like small shops, restaurants, and hotels. Other services include public administration, education, health, and community services. The SAM does not distinguish between informal and formal sectors. However, most of the sectors listed above (especially the agricultural, transport, and commerce sectors) contain a combination of formal and informal activities. This is worth mentioning because, like in many developing countries, the informal sectors represent a large share of the economic activity in Niger.

There are two factors of production: labor and capital. Labor is further divided into skilled and unskilled labor.

Six domestic institutions are distinguished in the SAM: five household groups and the government. The household groups are differentiated according to skills and sectors of activity. The five household groups are agricultural, skilled, unskilled, informal, and capitalist. Agricultural households engage in activities such as farming, livestock, and fisheries. They live primarily in rural areas. The informal households are employed in the informal sector and live mostly in urban areas. Capitalist households are households with mixed income; they receive wages and interest. Skilled households are households whose members have at least ten years of education; they primarily work in the formal sector and live in urban areas. Unskilled households are households whose members have zero to nine years of education and work in the formal sector.

In addition the SAM explicitly accounts for the following types of taxes: direct taxes, production taxes, import taxes, export taxes, and other taxes. Government income is the sum of these taxes plus foreign remittances.

2.2 Model Equations

The Niger CGE model comprises a system of linear and non-linear equations. The specification of the model follows closely the model developed by Dervis et al. (1982), Robinson, Naude, Hinojosa, Lewis and Devarajan, (1999), and Lofgren, Harris and Robinson, (2002). The model is based on two important principles of economics: optimization and equilibrium. It describes the behavior of economic agents, the constraints they face, and the equilibrium conditions in various markets. The equations of the model are presented in the following order: supply, price, income, expenditure, investment dynamic, and market equilibrium and closure.

2.2.1 Supply

The production of domestic goods is represented by a nested production function as described in equations (1) through (3).

$$X_{it} = VA_{it} + V_{it} \tag{1}$$

$$V_{it} = \sum_{j} a_{ij} X_{it} \tag{2}$$

$$VA_{it} = A_{it} LUS_{it}^{\alpha_{1i}} LS_{it}^{\alpha_{2i}} K_{it}^{1-\alpha_{1i}-\alpha_{2i}} \tag{3}$$

At the top level, sectoral production (X_{it}) is the sum of value added (VA_{it}) and demand for intermediate inputs (V_{it}), equation (1). Value added is a Cobb-Douglas production function of skilled labor (LS_{it}), unskilled labor (LUS_{it}) and capital (K_{it}) which is assumed fixed in a given period. Intermediate input requirements are fixed according to input-output coefficients (a_{it}), equations (2) and (3). Producers are assumed to maximize profit. In a competitive market, factors of production are paid the value of their marginal product.

$$PV_{it}\alpha_{1i}\frac{X_{it}}{LU_{it}} = WUS_{it} \quad (4)$$

$$PV_{it}\alpha_{21i}\frac{X_{it}}{LS_{it}} = WS_{it} \quad (5)$$

Equations (4) and (5) show the implicit demand for skilled and unskilled labor derived from the first order condition of profit maximization. The model solves for average skilled and unskilled wages that clear both types of labor markets in each sector.

$$X_{it} = A_{ED}\left[\lambda_{ED}E_{it}^{-\rho_{ED}} + (1-\lambda_{ED})D_{it}^{-\rho_{ED}}\right]^{\frac{-1}{\rho_{ED}}} \quad (6)$$

$$E_{it} = D_{it}\left[\left(\frac{PWE_{it}}{PD_{it}}\right)\left(\frac{1-\lambda_{ed}}{\lambda_{ed}}\right)\right]^{\sigma_{ed}} \quad (7)$$

$$Q_{it} = A_Q\left[\lambda_Q M_{it}^{-\rho_Q} + (1-\lambda_Q)D_{it}^{-\rho_Q}\right]^{\frac{-1}{\rho_Q}} \quad (8)$$

$$M_{it} = D_{it}\left[\left(\frac{PM_{it}}{PD_{it}}\right)\left(\frac{1-\lambda_Q}{\lambda_Q}\right)\right]^{\sigma_Q} \quad (9)$$

Equations (6) through (9) describe the international trade part of the model. The small country assumption holds for Niger's economy. Equation (6) shows the constant elasticity of transformation (CET) between the quantity of production that is exported and the quantity that is sold domestically. Producers maximize revenue from sales subject to the CET function. The first order condition is represented in equation (7), the export supply function which depends on relative prices ($\frac{PWE_{it}}{PD_{it}}$), where (PWE_{it}) is the world price of export and (PD_{it}) is the domestic prices, on share parameters (λ_{ed}), and on transformation elasticity (ρ_{ed}). The so called Armington (1969) aggregation function for composite goods is presented in equation (8). It shows an imperfect substitutability between imported goods and domestically produced goods. Consumers minimize the cost of acquiring the composite goods subject to imperfect substitutability. The first order condition of cost minimization yields to equation (9), which is the import demand equation. Import demand depends on relative prices ($\frac{PM_{it}}{PD_{it}}$), where (PM_{it}) is the price of import, on share parameters (λ_e), and on the Armington substitution parameters (σ_e).

2.2.2 Prices

$$PM_{it} = \overline{pw_i}(1+tm_i)ER \quad (10)$$

Equation (10) defines the price of imports. The world price ($\overline{pw_i}$), expressed in dollars, is exogenous due to the small country assumption for Niger. The domestic price of imports is equal to the world price of imports times one plus the import tariffs (tmit) times the exchange rate (ER).

$$PWE_{it} = \frac{PD_{it}}{(1+te_i)ER} \quad (11)$$

$$PQ_{it} = \frac{\left[PM_{it}M_{it} + D_{it}PD_{it}\right]}{Q_{it}} \quad (12)$$

$$PV_{it} = PD_{it}(1-tau) - \sum_j PQ_{jt}a_{ij} \quad (13)$$

$$CPI_{it} = \sum_{i=1}^{n} fc_i PQ_{it} \quad (14)$$

The export price equation (11), is the domestic price divided by 1 plus the export subsidy (which is zero in Niger) times the exchange rate. Equation (12) describes the price of composite good Q (PQ_{it}) which is a CES aggregation function of domestic (D) and import (M) goods supplied to the domestic market. Equation (13) defines the value-added prices or net-prices (PV_{it}), which are equal to the domestic price minus unit indirect taxes (*tau*) and the unit cost of intermediate inputs (based on the fixed input-output coefficients). Finally, equation (14) shows the consumer price index (CPI_{it}), which is equal to the weighted sum of composite prices, where the weight is the share (fc_i) of each commodity in total consumption.

2.2.3 Income and Saving

Equations (15) and (16) describe the wages for skilled and unskilled labor.

$$YLS_t = \sum_i WS_{it} LS_{it} \tag{15}$$

$$YLUS_t = \sum_i WUS_{it} LUS_{it} \tag{16}$$

The wage for skilled labor (YLS_t) is equal to the sum across sectors of wage rate times the amount of labor in each sector. The wage for unskilled labor ($YLUS_t$) is calculated similarly.

$$YK_i = \sum_i \left(PV_{it} VA_{it} - WS_{it} LS_{it} - WUS_{it} LUS_{it} \right) \tag{17}$$

Capital income (YK_t) in equation (17) is the residual after subtracting the wages from the value added.

$$Hinc_{ht} = (YLS_t HFSH_1 + YLUS_t HFSH_2 + YK_t HFSH_3 + \overline{WTH} * ER + \overline{GTH}) * (1 - t) \tag{18}$$

Equation (18) shows household disposable income ($Hinc_{it}$). Household income is composed of wages and profit received from labor services and capital investment, government transfers ($\overline{GTH}$), and remittances received from abroad ($\overline{WTH}$).

$$YG_t = \sum_h Hinc_h * t + \sum_i X_{it} * tau_i + \sum_i M_{it} * tm + \sum_i X_{it} * tex + \overline{WTG} * ER \tag{19}$$

Households pay income taxes, which are added to government income (YG_{it}) in equation (19). In addition to household income taxes, the government collects indirect taxes (or value-added taxes), import tariffs, and export taxes, which are included in equation (19). Finally, the Government receives remittances from abroad in the form of grants or no-interest loans ($\overline{WTG}$).

$$GDP_t = YLS_t + YLUS_t + YK_t + YG_t - (Fsav_t - \overline{WTG} - \overline{WTH}) * ER \tag{20}$$

Then nominal GDP in equation (20) is defined as the sum of skilled and unskilled wages, capital income, and government income minus foreign saving ($Fsav_t$), and the remittances received by both the government ($\overline{WTG}$) and the households ($\overline{WTH}$).

$$RGDP_t = \frac{GDP_t}{CPI} \tag{21}$$

$$Exp\inf_t = {100 * (CPI - CPI_o)}/{CPI_o} \tag{22}$$

$$R_t = No\min t_t - Exp\inf_t \tag{23}$$

Real GDP in equation (21) is obtained by dividing the nominal GDP by the consumer price index. The percentage change in the consumer price index is equal to the inflation rate ($Exp\inf_t$) as given in equation (22). The real interest rate (R_t) in equation (23) is obtained by subtracting the rate of inflation from the nominal interest rate.

$$Hsav_{ht} = MPS_H * Hinc_H \tag{24}$$

$$GS_t = YG_t - G\exp_t \tag{25}$$

$$TS_t = \sum_h Hinc_{ht} + GS_t + Fsav_t * ER \tag{26}$$

Equation (24) shows that household savings ($Hsav_t$) is equal to household income times the marginal propensity to save (MPS_h). Government savings (GS_t) in equation (25) is equal to government income minus government expenditures. Equation (26) shows total savings (TS_t). It is equal to household savings plus government saving plus foreign savings which is assumed endogenous.

2.2.4 Expenditures

$$CH_{it,h} = \gamma_{it,h} + \frac{\beta_{i,h}}{PQ_{it}} \left[\left(Hinc_{t,h} - Hsav_{t,h} \right) - \sum_j PQ_j \gamma_{j,h} \right] \tag{27}$$

$$Gcom_{it} = \frac{gcfc_i * GC_{it}}{PQ_{it}} \quad (28)$$

$$TC_{it} = \sum_h CH_{it,h} + Gcom_{it} \quad (29)$$

$$G\exp_t = \sum_i PQ_{it} Gcom_{it} + GTH * CPI + GTW * ER \quad (30)$$

The above equations shows the expenditure equations, which are household consumption demand (equation 27), government consumption (equation 28), total consumption (equation 29), and government expenditures (equation 30). The household consumption demand function ($CH_{it,h}$) is given by a linear expenditure system (as shown in equation 27) derived from Stone-Geary utility function, where, $\gamma_{i.h}$ are the committed expenditures or the "subsistence minima" (Note 2) and the term $\left[(Hinc_{t,h} - Hsav_{t,h}) - \sum_j PQ_j \gamma_{j,h}\right]$ is known as "uncommitted" or "supernumerary" income which is spent in fixed proportions $\beta_{i,h}$ between the commodities. $\beta_{i,h}$ are the marginal budget shares. The marginal budget shares determine the allocation of the income that remains after satisfying the "substance minima." It tells how expenditures on each commodity changes as income changes. Since $1 > \beta_i > 0$, the linear expenditures system does not allow for inferior goods. Government demand for final goods ($Gcom_{it}$) is defined as fixed shares ($gcfc_i$) of aggregate real government spending on goods and services (GC_{it}). Total consumption (TC_{it}) is the sum of household consumption plus government consumption. Government expenditure ($Gexp_t$) is composed of government consumption, government transfers to households, and government transfers to the rest of the world.

2.2.5 Investment

Aggregate investment in equation (31) is equal to total saving in the economy plus foreign saving. Moreover, aggregate investment is divided in two parts: investment by sector of destination and investment by sector of origin.

$$Z_{it} = H_{it} \frac{TS_t}{U_{it}} \quad (31)$$

Equation (31) describes investment by sector of destination (Z_{it}) which is equal to investment shares (H_{it}) times the total savings divided by a vector of capital prices (U_{it}).

$$Zo_{it} = \sum_j s_{ij} Z_{jt} \quad (32)$$

Investment by sector of origin (Zo_{it}) is derived from investment by sector of destination by using the capital composition matrix (s_{it}) (Note 3) as illustrated in equation (32).

$$H_{i,t-1} = SP_{i,t-1} + SP_{i,t-1}\left(\frac{R_{i,t-1} - AR_{t-1}}{AR_{t-1}}\right) \quad (33)$$

Sectoral investment share ($H_{i,t-1}$) is a function of the sectoral share of aggregate profit (Sp_{it}) and the profit rate differential ($\left(\frac{R_{i,t-1} - AR_{t-1}}{AR_{t-1}}\right)$) as illustrated in equation (33).

$$R_{it} = \frac{YK_{it}}{U_{i,t-1} K_{i,t-1}} \quad (34)$$

The sectoral profit rate (R_{it}), as illustrated in equation (34), is equal to the return to capital.

$$SP_{it} = \frac{Yk_{it}}{Yk_t} \quad (35)$$

Aggregate profit share is the ratio of profit in sector i to the total sectoral profit as described in equation (35).

$$AR_t = \sum_{i=1}^{n} SP_{it} R_{it} \quad (36)$$

Equation (36) shows the average nominal profit rate (AR_{it}), which is a weighted sum of the profit rate using the sectoral share of aggregate profit as the weight.

$$U_{it} = \sum_{j=1}^{n} s_{ji} PQ_{ji} \quad (37)$$

The price of capital (U_{it}) in equation (37) is a weighted sum of the composite price and capital composition matrix.

$$K_{i,t+1} = K_{0,it} + Z_{it} \tag{38}$$

Finally, the next period capital stock ($K_{i,t+1}$) in equation (38) is equal to the initial capital stock plus investment by sector of destination.

2.2.6 Income Distribution and Welfare Measures

There are many measures of income inequality. The most commonly used are the Gini coefficient, Theil index, the Atkinson's index, and the coefficient of variations. The Gini coefficient is the most popular measure of income inequality (Note 4). It allows one to examine the change in income distribution of households. The Gini coefficient ranges from 0 to 1. When the Gini coefficient is equal to 0 then income is equally distributed among households. This condition is known as perfect equality. A Gini coefficient of 1 represents a situation where all the incomes are held by one household group, referred to perfect inequality.

$$Gini = \frac{1}{2n^2 Hincbar}\sum_i \sum_j \left|Hinc_i - Hinc_j\right| \tag{39}$$

To capture the effect of different policy scenarios on income inequality, the present study uses the Gini coefficient as a measure of inequality (equation 39). The present model uses representative household groups with the assumption of income homogeneity in each household group. Therefore, the Gini coefficient computed in this study measures the inequality across the five representative household groups.

Policy analysts often refer to welfare indicators to evaluate the impact of a policy change. The most commonly used of welfare indicators are the consumer surplus, the compensating variation, and the equivalent variation. The consumer surplus is mostly used in cases where the price of only one good changes. It is also very easy to compute. However, the consumer surplus is not well defined when there are multiple price changes or a simultaneous change in income and price. Unlike the consumer surplus, the compensating variation (CV) and the equivalent variation (EV) do not suffer from the above shortfall, which makes them very attractive. CV is the amount of money which, when taken away from the consumer after the price change and income change, leaves him with the same level of utility as before the change. EV is the amount of money which, when paid to the consumer, achieves the same level of utility before the change that would be enjoyed with the economic change.

$$EV_{ht} = \prod_i \frac{PQ_{o,it}}{PQ_{it}} Hinc_h - Hinc_{o,h} \tag{40}$$

To gauge the impact of the simulations on the welfare of each representative household group, equivalent variations (a measure commonly used in CGE models) were computed as shown in equation 40. The equivalent variation is a function of initial income and initial composite prices ($Hinc_{o,h}$, $PQ_{o,it}$) and the new income and new composite prices ($Hinc_h$, PQ_{it}).

2.2.7 Market Clearing Conditions and Macroeconomic Closure

Indeed, for the model to be complete, it must satisfy a system of constraints: supply-demand equilibrium conditions and the macroeconomic closure rule.

$$Q_{it} = INT_{it} + CH_{it,h} + Gcom_{it} + Z_{it} \tag{41}$$

Equation (41) shows the equilibrium condition in the product markets. In a competitive market, prices adjust to clear the factor and product markets. The equation states that the supply of each composite good must equal its demand. Domestic price (PD_{it}) adjust to bring about equilibrium in the market for each good.

$$LUS_{it}^D = LUS_{it}^S \tag{42}$$

$$LS_{it}^D = LS_{it}^S \tag{43}$$

Equations (42) and (43) state that the supply of skilled and unskilled labor equals their respective demand. The average skilled and unskilled wage rates adjust to clear the skilled and unskilled labor market. Capital is assumed fixed in each sector during the current year.

$$Fsav_t = \sum_i PM_{it} M_{it} - \sum_i PWE_{it} E_{it} \tag{44}$$

$$TS_t = \sum_i Z_{it} \tag{45}$$

Equations (44) and (45) describe macroeconomic equilibrium conditions for the balance of payments and saving-investment balances. Niger has a fixed exchange rate, so the choice of foreign exchange market closure is important. Equation (45) shows that foreign capital inflow ($Fsav_t$) is equal to the difference between total imports and total exports. With a fixed exchange rate, foreign capital inflow will have to adjust to bring the balance of payments in equilibrium. Equation (45) describes the neoclassical closure, where aggregate saving is equal to total investment.

2.3 Data and Calibration

The next step in building most CGE models is to calibrate the equations using data for one period. Although, one could use econometric techniques to estimate some of parameters, the lack of data makes this an elusive quest. Like most CGE models, this model utilizes the information contained in the SAM to calibrate most of the parameters. The parameters that could not be calibrated using Niger's SAM were borrowed from other studies.

As mentioned earlier, a 2004 SAM was obtained from the National Institute of Statistics. The CGE model must satisfy the various identities included in the SAM. In fact, calibration involves a process of finding a set of parameters and exogenous variables so the CGE model replicates data contained in the SAM (Note 5). For example, the following parameters were calibrated using the data in the SAM: the share of unskilled and skilled labor (α_{1i}, α_{2i}) in production, the technology factor (A_i), and the marginal propensity to save (MPS) for each of the representative household groups.

The imports and exports are represented by CES functions. The three unknown parameters for a typical CES function are the shift parameter (A), the share parameter (λ), and the elasticity parameter (ρ). Following tradition in CGE modeling, the trade elasticity parameters were borrowed from Decaluwe et al. (2004). These elasticities were then used along with the information contained in the SAM to calibrate the shift and share parameters. For example, the share parameter (λ_e) and the shift parameter (A_e) of composite goods are calibrated by respectively solving for λ_e in equation 9 and A_e in equation 8 as illustrated in equation 46 and 47.

$$\lambda_Q = \frac{\left(\frac{PM_i}{PD_i}\right)\left(\frac{M_i}{D_i}\right)^{\frac{1}{\sigma_Q}}}{1+\left(\frac{PM_i}{PD_i}\right)\left(\frac{M_i}{D_i}\right)^{\frac{1}{\sigma_Q}}} \tag{46}$$

$$A_Q = \frac{Q_i}{\left[\lambda_Q M_{it}^{-\rho_Q} + (1-\lambda_Q) D_{it}^{-\rho_Q}\right]^{\frac{-1}{\rho_Q}}} \tag{47}$$

The parameters of export function are calibrated in a similar fashion.

As mentioned earlier, the household consumption function is represented by a linear expenditure system. The CGE model requires full specification of the linear expenditure system (LES). The calibration of LES involves the use of exogenous parameters: the "substance minima" and the marginal budget share. These parameters can either be estimated (if data are available) or borrowed from the literature.

The calibration process for the linear expenditure system starts by computing the average budget shares. These shares are obtained by dividing the consumption expenditures for sector i by the total consumption expenditure. The present study uses exogenously specified income elasticity (η_i) of demand and a parameter measuring the elasticity of marginal utility of income with respect to income (ω), known as the Frisch parameter (Frisch, 1959), to compute the LES parameters. The Frisch parameters are given by the following formula:

$$\omega_h = -\left(Hinc_h - Hsav_h\right) \Big/ \left[\left(Hinc_h - Hsav_h\right) - S\right] \tag{48}$$

Where

$$S = \sum_j PQ_j \gamma_{j,h}$$

The income elasticities are given by:

$$\eta_{i,h} = \beta_{i,h} * (Hinc_h - Hsav_h) \Big/ PQ_{it} * CH_{i.h} \tag{49}$$

The estimates of the Frisch and income elasticities are based on various cross-country studies, especially that of

Dervis et al. (1982). With the Frisch and income elasticities parameters estimated, the computation of marginal budget shares and "subsistence minima" is straightforward. The "subsistence minima" (equation 50) is obtained by solving equation 46 and using the information contained in equation 50:

$$\gamma_{i,h} = CH_{i,h} + \left(\sum_{i} CH_{i,h} * \eta_{i,h} / \omega_h \right) \tag{50}$$

Manipulating equation 50 yields the formula for computing the marginal budget (equation 51) share as follows:

$$\beta_{i,h} = \eta_{i,h} * PQ_{ij} * C_{i,h} / \left(Hinc_h - Hsav_h \right) \tag{51}$$

3. Simulation Results

The model is first run for twelve years, from 2004 to 2015, with the assumption that there is no natural resource windfall (the Baseline Scenario), and then the model is used to simulate the impact of the windfall (Simulation I). In Simulation I, the economy is injected with 78.54 (Note 6) billions of CFA. The objective in Simulation I is to mimic the current government policy, which consists of distributing part of the windfall revenue to households and spending the rest. The government is assumed to seize 1/3 of the amount and transfer 2/3 to each representative household group according to a transfer parameter computed using the information contained in the SAM.

This Section is divided as follows. First, the baseline results are compared with Simulation I to see the impact on the key macroeconomic variables (real GDP, Saving, CPI), and then the impact on household welfare and income inequality.

3.1 The Impact of the Windfall on Key Macroeconomic Variables

Table 2. Macroeconomic impact of natural resource windfall

	2005	2006	2007	2008	2009	2010
Real GDP	0.20%	4.15%	10.85%	12.08%	11.71%	13.16%
CPI	0.10%	2.76%	9.38%	9.74%	10.15%	13.66%
Nominal Wages	0.19%	18.69%	62.55%	67.87%	67.04%	86.11%
Government Income	0.03%	3.72%	12.31%	13.63%	14.68%	19.54%
Capital Income	11.92%	23.98%	54.33%	57.68%	57.30%	71.47%
Private Saving	1.30%	36.04%	120.86%	130.68%	123.00%	152.77%
Public Saving	364.60%	243.17%	491.55%	431.20%	311.18%	316.64%
Total Saving	8.75%	39.66%	116.78%	124.69%	117.45%	144.45%
Total Investment	8.74%	38.93%	106.06%	94.87%	84.41%	108.07%
Export	2.53%	14.27%	41.43%	42.43%	41.79%	54.52%
Import	2.67%	13.99%	40.75%	43.10%	43.11%	55.87%
Sectoral Production	3.25%	14.92%	42.55%	43.62%	43.21%	56.47%

Table 2. Continued

	2011	2012	2013	2014	2015
Real GDP	13.65%	11.40%	12.07%	10.73%	10.57%
CPI	14.59%	12.62%	14.15%	13.34%	14.09%
Nominal Wages	91.49%	73.17%	81.81%	72.52%	74.01%
Government Income	21.15%	18.84%	21.05%	20.12%	21.07%
Capital Income	75.50%	62.75%	69.54%	63.07%	64.58%
Private Saving	160.26%	119.14%	133.47%	112.12%	112.32%
Public Saving	299.71%	194.41%	207.09%	159.94%	152.59%

Total Saving	150.78%	113.62%	126.49%	107.09%	107.25%
Total Investment	107.19%	75.77%	91.13%	74.00%	75.64%
Export	57.22%	46.43%	52.99%	47.65%	49.36%
Import	59.17%	48.79%	54.88%	49.79%	51.38%
Sectoral Production	59.37%	48.53%	55.05%	49.69%	51.30%

Table 2 summarizes the impact of the experiment on selected macroeconomic variables. Real GDP increases in Simulation I relative to the baseline as a result of the natural resource windfall. On average, real GDP changes from the baseline by 10 percentage points, which indicates that the windfall is growth promoting. The natural resource windfall widens the real GDP gap between the baseline and Simulation I. This is an important finding because contrary to the natural resource curse hypothesis, this windfall improved real GDP.

Real GDP increases in Simulation I relative to the baseline as a result of the natural resource windfall. On average, real GDP changes from the baseline by 10 percentage points, which indicates that the windfall is growth promoting. The natural resource windfall widens the real GDP gap between the baseline and Simulation I. This is an important finding because contrary to the natural resource curse hypothesis, this windfall improved real GDP.

The increase in real GDP is primarily due to an increase in the total amount of savings available in the economy. Indeed, the assumption in Simulation I is that 1/3 of the windfall is seized by the government. Furthermore, government consumption is held constant, which means that additional revenue collected by the government is saved rather than consumed. As a result, public savings more than tripled in 2005, following the windfall. Private savings also increased drastically from the baseline because households receive 2/3 of the windfall from the government. The government transfer increases household income, which translates into higher savings given a fixed marginal propensity to save. In addition, total nominal wages increase, which also increases household income and therefore increases the level of household savings. After a small jump in 2005, total saving increased significantly compared to the baseline scenario.

The increase in total nominal wages is due to two main factors. First, the model is a full employment model, meaning there is no unemployment. The wage rate adjusts to equate the supply and demand for labor. The demand for labor increases as the capital available for producers increases. This creates an upward pressure on wages. Second, the value-added price results in higher nominal wages.

As one would expect, the increase in saving translates into an increase in total real investment in the economy. For example, total real investment increases by 75% in 2015 compared to the baseline. Total sectoral profit as measured by capital income also increases as a result of the windfall.

The increase in economic activities due to the inflow of natural resource revenue results in a rise in the average level of prices compared to the baseline scenario. The consumer price index (CPI) increases; further, the difference increases so that the rate of inflation (Note 7) increases. The gap between the baseline CPI and Simulation I CPI increases. This result confirms the spending effect associated with the Dutch disease hypothesis, which states that an increase in a natural resource windfall tends to increase demand for goods and services, thereby increasing relative prices.

3.2 Household Welfare and Income Distribution

The objective of this section is to analyze the impact of a natural resource windfall on household welfare and income distribution in Niger. There are five representative household groups in the model. Tables 2 and 3 summarize the impact of a natural resource windfall on each representative household income and real consumption respectively.

Table 3. Total household income

	Agricultural Household			Skilled Household			Unskilled Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	469.514	469.514	0.00%	163.255	163.255	0.00%	319.229	319.229	0.00%
2005	508.567	541.218	6.42%	417.673	420.624	0.71%	347.142	350.162	0.87%
2006	538.254	608.202	13.00%	517.129	760.011	46.97%	368.57	398.259	8.06%
2007	552.269	712.714	29.05%	509.459	1332.563	161.56%	378.787	473.191	24.92%
2008	569.973	747.126	31.08%	528.075	1449.751	174.54%	391.634	498.003	27.16%
2009	597.9	787.384	31.69%	616.444	1597.97	159.22%	411.783	527.003	27.98%
2010	624.322	873.167	39.86%	696.372	2046.663	193.90%	430.854	588.543	36.60%
2011	645.542	918.88	42.34%	741.657	2239.344	201.94%	446.207	621.428	39.27%
2012	691.305	945.043	36.70%	944.045	2302.373	143.88%	479.109	640.34	33.65%
2013	708.65	994.689	40.36%	963.112	2518.109	161.46%	491.693	676.039	37.49%
2014	756.298	1042.04	37.78%	1173.617	2720.468	131.80%	525.951	710.097	35.01%
2015	787.932	1095.074	38.98%	1281.34	2958.062	130.86%	548.758	748.219	36.35%

Table 3. Continued

	Informal Household			Capitalist Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	434.379	434.379	0.00%	144.134	144.134	0.00%
2005	473.077	481.803	1.84%	156.244	164.056	5.00%
2006	502.314	547.993	9.09%	164.819	184.012	11.64%
2007	516.004	651.343	26.23%	169.185	215.999	27.67%
2008	533.354	685.229	28.48%	174.773	226.719	29.72%
2009	560.84	724.891	29.25%	183.471	239.372	30.47%
2010	586.837	809.676	37.97%	191.712	265.862	38.68%
2011	607.679	854.764	40.66%	198.394	280.09	41.18%
2012	652.834	880.473	34.87%	212.59	288.418	35.67%
2013	669.833	929.451	38.76%	218.101	303.912	39.34%
2014	716.849	976.16	36.17%	232.916	318.682	36.82%
2015	747.998	1028.496	37.50%	242.821	335.201	38.04%

Table 3 shows that household incomes improve significantly. This increase can be explained by the fact that in Simulation I the government transfers 2/3 of the windfall to the households. Furthermore, the increase in nominal wages and capital income mentioned earlier contribute to the significant increase in household income.

However the increase in household income is not evenly distributed across household groups. There is an increase in the Gini coefficient, which indicates raising inequality. The increase in income inequality is primarily due to the relative increase in skilled household income. For example, by the end of 2015 skilled household income increases by 130% compared to only 36% for unskilled household income. The result can not be explained by the share of total government transfer to skilled households, which is relatively small compared to the other household groups. However, the wages received by the skilled households increase dramatically in Simulation I, reflecting the increased productivity of skilled labor. The skilled wages are increasing at a faster rate than the unskilled wages.

Table 4. Total real consumption by household group

	Agricultural Household			Skilled Household			Unskilled Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	451.257	451.257	0.00%	94.272	94.272	0.00%	277.671	277.671	0.00%
2005	490.272	521.981	6.47%	237.172	238.802	0.69%	306.339	308.983	0.86%
2006	516.636	575.425	11.38%	291.528	423.87	45.40%	324.62	347.89	7.17%
2007	530.394	656.681	23.81%	287.167	735.406	156.09%	333.431	407.361	22.17%
2008	546.482	688.111	25.92%	297.08	800.093	169.32%	344.09	428.778	24.61%
2009	570.296	721.505	26.51%	345.084	879.172	154.77%	360.576	451.887	25.32%
2010	593.438	790.127	33.14%	388.664	1122.22	188.74%	376.47	500.96	33.07%
2011	612.766	830.11	35.47%	413.418	1227.686	196.96%	389.477	528.509	35.70%
2012	650.566	854.331	31.32%	523.25	1261.385	141.07%	416.114	544.478	30.85%
2013	667.563	896.54	34.30%	534.04	1377.807	158.00%	427.27	573.615	34.25%
2014	707.193	937.662	32.59%	648.097	1487.611	129.54%	455.027	601.836	32.26%
2015	735.323	983.234	33.71%	706.876	1616.248	128.65%	474.23	633.22	33.53%

Table 4. Continued

	Informal Household			Capitalist Household		
	Baseline	Simulation I	% Change	Baseline	Simulation I	% Change
2004	419.095	419.095	0.00%	140.592	140.592	0.00%
2005	466.411	475.017	1.85%	148.543	156.048	5.05%
2006	495.863	539.206	8.74%	154.635	166.82	7.88%
2007	508.906	637.11	25.19%	159.212	183.858	15.48%
2008	525.019	670.686	27.75%	164.219	192.501	17.22%
2009	550.931	706.979	28.32%	170.625	201.711	18.22%
2010	575.813	786.521	36.59%	176.987	217.822	23.07%
2011	595.834	830.079	39.31%	182.702	228.556	25.10%
2012	638.464	854.349	33.81%	192.157	236.24	22.94%
2013	655.317	900.425	37.40%	197.544	247.62	25.35%
2014	699.605	944.933	35.07%	207.683	258.847	24.64%
2015	729.673	994.596	36.31%	215.53	271.128	25.80%

Table 4 presents the effect on household real consumption. The results show that each representative household group experiences an increase in real consumption. Indeed, as household incomes increase, so does household real consumption, holding marginal propensity to consume constant before and after the simulation. Just as household incomes are not evenly distributed, household real consumption also differs across household groups. Skilled households have the highest increase in consumption as opposed to capitalist households. For example, from the baseline to Simulation I, skilled household consumption increases by 128% in 2015 as opposed to 25.80% for capitalist households.

Table 5. Welfare impact of windfall: 12 years average of equivalent variation

	Agricultural Household	Skilled Household	Unskilled Household	Informal Household	Capitalist Household
Baseline	24.10	88.05	18.52	26.26	6.30
Simulation I	45.01	217.76	33.49	48.47	10.93

To assess the impact of the windfall on household welfare equivalent, variations were computed using equation (40). The results of the welfare impact of the natural resource windfall (in Table 5) show that on average over the twelve years, all the household groups benefit from a natural resource windfall. However the welfare of skilled households improves relatively more compared to the welfare of other household groups because of the relative increase in skilled household income.

4. Conclusion

This study developed a dynamic computable general equilibrium model to investigate the impact of a natural resource windfall on Niger's economy. To capture the socio-economic impact from natural resource windfall, the study considered the impact on real GDP, consumer price index (CPI), household welfare, and income distribution (the Gini coefficient). The main findings are as follows.

First, a natural resource windfall turns out to significantly increase the overall level of real GDP. Based on the simulation, there are two possible reasons for this result. The first reason is that half of the windfall is saved by the government, which substantially increases public saving. Second, households also save part of the transfer received from the government, which increases private saving. These two effects substantially increase total saving, thereby increasing sharply the capital stock and thus real GDP. Second, household income increases significantly, which translates to higher consumption and therefore a welfare improvement. However, the increase in income is not evenly distributed, which explains the relative increase in the Gini coefficient.

Regarding the CPI, this study finds that the overall price level increases but not the long-run inflation rate. This is primarily due to spending effects. This result is very interesting because it shows some indication of Dutch disease.

The government of Niger should definitely consider spending a big share of the natural resource windfall on education and infrastructure, considering the poor infrastructure and the high rate of unskilled labor in the country. In this regard, Niger's government has recently announced that it will invest more than 12 billion CFA to reduce its dependency on foreign energy. In addition, the government has secured funds for the Kandadji project, which will allow the country to produce its own electricity and irrigation schemes to reduce the risks associated with climate variability

References

Benjamin, N., Devarajan, S., & Weiner, R. J. (1989). The Dutch disease in a developing country: Oil reserve in Cameroon. *Journal of Development Economic, 30*, 71–92. http://dx.doi.org/10.1016/0304-3878(89)90051-5

Corden, W. M. (1984). Booming sector and Dutch disease economics: Survey and consolidation. *Oxford Economic Papers, 36*, 359–380.

Corden, W. M., & Neary, J. P. (1982). Booming sector and Dutch disease economics: A survey. *Economic Journal, 92*, 825–880. http://dx.doi.org/10.2307/2232670

Cowell, A. F. (1998). Measuring inequality. *London School of Economics Discussion Pape*r, *3*. Retrieved from http://darp.lse.ac.uk/papersDB/Cowell_measuringinequality3.pdf

Dervis, K., Melo, J. D., & Robinson, S. (1982). *General equilibrium models for development policy*. Washington, DC: World Bank.

Gylfason, T. (2007). The international economics of natural resources and growth. *Minerals & Energy, 22*, 1404–1049. http://dx.doi.org/10.1080/14041040701445882

Krugman, P. (1987). The narrow moving band, the Dutch disease and competitive consequences of Mrs Thatcher: notes on trade in the presence of dynamic scale economies. *Journal of Development Economic, 27*, 41–55. http://dx.doi.org/10.1016/0304-3878(87)90005-8

Lofgren, H., Harris, R. L., & Robinson, S. (2002). *A Standard computable general equilibrium (CGE) model in GAMS*. Washington, DC: International Food Policy Research Institute. Retrieved from http://www.ifpri.org/sites/default/files/pubs/pubs/microcom/5/mc5.pdf

Partridge, D., & Rickman, D. (2010). CGE modeling for regional economic development Analysis. *Journal of Regional Studies, 44*, 1311–1328. http://dx.doi.org/10.1080/00343400701654236

Robinson, S., Naude, A. Y., Hinojosa, R., Lewis, J. D., & Devarajan, S. (1999). From stylized to applied models: building multisector CGE models for policy analysis. *The North American Journal of Economics and Finance, 10*, 5–38. http://dx.doi.org/10.1016/S1062-9408(99)00014-5

Ross, M. (2001). *Extractive sectors and the poor.* Oxfam America Report. Retrieved from http://www.oxfamamerica.org/files/extractive-sectors-and-the-poor.pdf

Sachs, J. D., & Warner, A. M. (1999a). The big rush, natural resource booms and growth. *Journal of Development Economics, 59*, 43–76. http://dx.doi.org/10.1016/S0304-3878(99)00005-X

Sachs, J. D., & Warner, A. M. (1999b). Natural resource intensity and economic growth. In Meyer, J., Chambers, B., & Farooq, A. (Eds.), *Development Policies in Natural Resource Economies.* Cheltenham: Edward Elgar.

Torvik, R. (2001). Learning by doing and the Dutch disease. *European Economic Review, 45*, 285–306. http://dx.doi.org/10.1016/S0014-2921(99)00071-9

Torvik, R. (2005). The optimal Dutch disease. *Journal of Development Economics, 78*, 495–515.

Wijnbergen, S. V. (1984). Inflation, employment, and the Dutch disease in oil-exporting countries: A short-run disequilibrium analysis. *The Quarterly Journal of Economics, 99*, 233–250. http://dx.doi.org/10.2307/1885524

Notes

Note 1. The inflow of capital need not to be only from a resource windfall. It can be from emigrant remittances, aid, or any other type of capital that can be categorized as a foreign exchange gift.

Note 2. Subsistence expenditures are defined as the minimum household expenditure on a particular food commodity or group of commodities.

Note 3. The capital composition matrix is composed of coefficients describing the make up of sectoral capital stock.

Note 4. Cowell (1998) has an excellent overview of the pros and cons of each of these measures.

Note 5. For more discussion on CGE calibration processes see Robinson et al. (1999).

Note 6. This is the exact amount that Niger's government received from exporting uranium in 2005.

Note 7. Since the model does not have a monetary component, inflation in this study is the percentage CPI, which is just the weighted sum of relative composite prices.