

# Oil Boom and Public Investment in Chad

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## Abstract

This paper deals with the issue of natural resources management in Chad. Using a CGE model, I analyze the impact of public investment in irrigation and road infrastructures. Suggesting different uses of the oil revenue expected for the next ten years, this study compares several agricultural policies in terms of economic growth. Taking into account the integration of markets, it explains why the improvement of water access prevents the gap between urban and rural areas from growing, reduces the Chadian dependence on food aid and entails a substantial growth in rural household welfare.

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## 1 INTRODUCTION

<sup>1</sup>Chad is among the poorest countries in the world. The United Nations Program for Development (UNDP) classified this country at the 164th rank over 175 according to the Human Development Indicator. Three quarter of its population lives below the poverty line. Nevertheless, according to Chad

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development partners, the primary sector presents considerable development potential. Further more, the oil boom expected in Chad in the years to come will generate a substantial annual income for the government, estimated to be approximately equivalent to the current international aid flow received each year.

But the different uses of the oil revenue expected for the next ten years can not be evaluated without a tool for quantitative analysis relevant in the case of a developing country. The policies suggested by the international organizations can not be analyzed from a macroeconomic point of view without a model that takes into account the behavior of the different economic agents, as well as a complex market functioning with a large part of informal exchanges.

Since this type of model has not been applied to the Chadian economy up to now, this study develops a Computable General Equilibrium Model for this purpose. This kind of general equilibrium model was initially developed by the economists of the World Bank and has now become currently used in other research centers. Adelman and Robinson constructed the first model for Korea in 1978 which became a reference for various models simulating the impact of economic policy on income distribution. Since they belong to the class of simulation tools, such models are particularly helpful in understanding the mechanisms and the stakes of policy choice. The parameters are obtained through a calibration process conducted for a given year. Their values are thus based on an empirical and theoretical analysis instead of an econometric study which requires long time series. On the other hand, the method prevents forecasting based on past situations which econometric models allow. Only simulations with comparative static analysis can answer policy choice questions. It will thus be necessary to test the sensitivity of the result in order to identify which parameters are determinant for the final result.

Like many models representing a Sub-Saharan country, the present CGEM is similar to those described by Dervis, DeMelo and Robinson (1982) or Collange and Calipel (1993) : it represents an open economy with a fixed exchange rate. However this model takes into account the high rate of penetration of industrial markets and therefore provides a particular approach to the price formation mechanism for each sector. In addition, an endogenous growth process occurs when some relevant investments are applied.

Based on the UNDP's very exhaustive reports and figures, as well as on data provided by other international institutions, the construction of the

social accounting matrix includes particular phenomena in order to be representative of the Chadian economy. Hence, it was necessary to determine some important flows such as the nature and real value of imports that are heavily underestimated in official statistics. The social accounting matrix that is proposed differentiates three production sectors and details government income and expenditure. It is thus possible to simulate the application of fiscal and budgetary measures that have been proposed by the IMF but not always followed by the Chadian government, so as to assess their relevance.

The study and simulation of the oil boom expected for the year 2001 allows the comparison of various policies because it provides an additional government income comparable to foreign aid. The purpose of this paper is to determine which investments the Chadian authority would have to undertake to avoid the occurrence of a Dutch Disease, which many less developed countries suffered as a consequence of an oil boom.

Concerning the construction of the theoretical framework of the model, it was necessary to decide on some assumptions concerning consumption and saving behavior as well as on elasticities relevant to the case of Chad.

For this purpose, a thorough econometric study of regional market integration has been run for the sectors of subsistence crops, informal sector products and industry on the whole Chadian cross border exchange area. The assumption tested concerns the determination of prices on these markets. The aim of this analysis was to check if the country, due to its small size and to the permeability of its frontiers, was in a price taker position, in which prices in border markets would be imposed for its markets. Thus, the determination of prices would be exogenous and the equilibrium would be achieved through quantity adjustments. This econometric study makes it possible to draw conclusions on the nature of the equilibrium for each sector. In particular it proves the independence of the subsistence crop market from external influence on prices.

I next consider two particular aspects of the agricultural sector :

- 1) Only 1% of the arable area is currently irrigated. Nevertheless, the problem is not the lack of water but rather the low capital intensity of the production process. This is why the question of investment is crucial in this sector, which represents large development potential.

- 2) Crop production in the South can, under favorable conditions, be sufficient to feed the whole Chadian population. But the lack of roads hinders the distribution of agricultural products that are currently being traded with

Cameroon. Considering this fact, it is easy to understand the importance of road infrastructure improvement.

These considerations clearly reveal the lack of these infrastructures as a serious impediment to growth. Thus, assuming that a part of the oil income will be devoted to these kinds of infrastructure, public expenditures are affecting the production functions of the relevant sectors. An endogenous growth process can then occur in the economy and can have substantial impact, especially on rural income.

Two kinds of investment options are considered:

-The first one concerns the impact of an irrigation policy. In this case, public investment affects the agricultural production function because it changes the amount of the total capital stock used in this sector.

-In the second option, the construction of a road linking the South to the north affects all sectors of the economy so that each production function must incorporate a technical progress improvement.

In both cases, it is possible to analyze the effect of each measure on the main economic indicators and more precisely on the Chadian dependence on aid and food assistance. I then analyze the complementarity of these two kinds of investment in order to suggest what part of the oil revenue should be dedicated to the agricultural sector. Considering that each kind of investment presents particular advantages in term of growth and household welfare, it is then possible to discuss what kind of policy should be adopted according to the importance given to rural household welfare.

How can the government target the poorest part of the Chadian population? Is it possible to reduce the diverging development trends between rural and urban areas in a oil boom period? This paper seeks to explain why some agricultural development policy can prevent the gap between rural and urban area from growing.

The studies on oil boom in developing countries are often pointing out the negative effects of this trade shock. Analyzed by Bevan, Collier and Gunning (87), the spending effect induces the decline of the tradable sectors. The present paper shows how these effects can be reversed by relevant investments in some public assets. In fact, the traditional conclusions of the literature on Dutch Disease explain why the benefits of the boom should be dedicated to private investment. However in the Chadian case, the oil revenue is totally owned and managed by the government. Assuming that the demand for

public goods is more important in developing countries and crucial for the households welfare, it is useful to find a relevant way to satisfy this demand.

The present study analyzes the effect of public investment in the agricultural sector. Nevertheless, its conclusion can be unchanged if the investment are financed by foreign aid or by micro-credit organisms. Hence, the conclusions of this paper do not exclusively concern Chad or a country in an oil boom period but can be applied to similar developing economies.

The following section offers a detailed description of the CGE model and justifies its assumptions relevant to the case of Chad. Section 3 presents the empirical works on public investment return. Then, after describing the modeling of the endogenous growth process, the paper presents the results on the impact of public investments according to their nature. Finally, an original rural development policy will be presented targeting both rural development and growth by diversifying public investments.

## 2 THE CONSTRUCTION OF THE MODEL

### 2.1 The Data and the Social Accounting Matrix

The survey on consumption and informal sector (ECOSIT) was completed between June 1995 and June 1996 on a population sample of 2600 households. They were chosen randomly in the main four cities of the country and on the rural surrounding of their prefectures. Initiated by the Statistics and Economic Division of the Chadian Ministry of Planning and Cooperation, this survey takes place in the Program "Appui à la gestion du développement". It was financed and directed by the United Nations Programme for Development (UNDP). Its originality lies in the synthetic picture of the Chadian economy that it draws. A special focus is set on two fields :

- first, the household income and expenditure and the behavior they induce,

- second, the product and characteristics of the informal activities that the households develop to respond to their needs and to accumulate capital.

ECOSIT constitutes the first statistical inquiry related to Chadian households living outside N'Djamena and focusing on non-demographic characteristics. The part concerning the informal sector is also unique compared to

other African surveys. This study leads to found a new national account basis because it provides new measures of the informal production units. It helps to take into account a large range of the Chadian Economy, never evaluated up to now. The previous national account was based on the year 1977. Until the result of ECOSIT were produced, there were no reliable database allowing an economic analysis of the Chadian Economy.

Based on the United Nations Programme for Development very exhaustive reports and figures as well as on some other data, which were provided by technical assistants of other international institutions, the social accounting matrix of this model takes into account some important flows such as the nature and real value of imports, very largely underestimated in official statistics. Constructed for the year 1995, it distinguishes five production sectors and details precisely government income and expenditure. Each flow, exchange or transfer of money, good or service occurring in the year 1995 is represented by a cell of the social accounting matrix. Each agent, market or production factor will be represented by a column and a row. The value in column  $i$  and row  $j$  is an expenditure for the agent or market represented by column  $i$  and revenue for the agent or market corresponding to row  $j$ . The sum of the expenditures of one column should be equal to the sum of the revenue of the corresponding row. In other terms, let's  $x_{ij}$  represent the amount in row  $i$  and column  $j$ . Then  $x_{ij}$  is an expenditure for the person  $i$  and a revenue for the person  $j$ , and

$$\sum_i x_{ik} = \sum_j x_{kj} \quad \forall k$$

Of course, the sum of all the rows is equal to the sum of all the columns, in other terms the sum of each type of expenditure equal the sum of each type of revenue.

## 2.2 The Production Process

Five sectors are distinguished :

- food crop
- cash crop
- industry
- informal sector
- commerce

The food crop sector is comprised of all the agricultural goods produced by the rural households, like cereals, oilseeds and vegetables in accordance with the Chadian nutrition traditions and uses. This sector also includes the cattle and the fishing production. Chad has a very important livestock that is estimated at 5 millions heads and that offers a considerable source of revenue, as explained in the section concerning export.

The cash crop sector corresponds to the cotton grain production industry. It has recently been privatized in accordance with the Structural Adjustment Facility agreed with the IMF. Located in the South, this production is the most modernized one in the country and is a very important source of economic dynamism in the area.

Industry includes the production of soap, sugar, cigarettes, oil, various beverages, principally beer. It also takes into account the production of water and electricity and construction.

The informal sector corresponds to the food transformation and the small-scale craft production principally the processing of wood and leather.

The commerce sector production is evaluated as the sum of the margin made on goods transport between local markets, and from foreign to national markets. In other words, it concerns the trade of domestic goods and imports.

Each production function assumes a Constant Elasticity of Substitution (CES) between the two factors of production, labor and capital :

$$X_i = A_i \left[ \alpha_i LD_i^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - \alpha_i) K_i^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}}$$

with  $LD_i$  : labor demand for sector  $i$ ,

$K_i$  : capital stock in sector  $i$ ,

$\sigma_i$  : substitution elasticity for sector  $i$ .

For the commerce sector, production can also be considered as the sum of profit margin made on domestic and foreign trade.

The capital stock is given by the initial situation but can be affected by the investments described below.

For each sector, intermediate consumption is given by the technical coefficient matrix, constructed thanks to the analysis of informal activities provided by the ECOSIT.

The amounts of production taxes is detailed across sectors in many reports on government resources (World Bank, IMF, French Embassy). Hence the rate for each sector is obtained by dividing the amount of the tax collected by the amount of total production.

Considering the payment of the production factor, two points are important to underline. First the amount of profit has been estimated as the difference between the total value of production less the cost of intermediate consumption, the payment of wages and taxes. An exogenous part of the profits is distributed to households so that only a fixed proportion of it is devoted to investment and so considered as saving. The total amount of profit is considered as the returns to the capital stock. Second, the non traded production consumed by the producer itself and not sold on any market is considered as an element of labor income.

## 2.3 The Labor Market :

The total quantity of labor is fixed but the workers can move across sectors according to a migration function. In the Harris and Todaro's theory of migration published in 1970, three kind of wages are distinguished:

- the rural wage concerns the workers of the food crop sector,
- the informal wage concerns the workers of the informal sector,
- the modern wage concerns the labor employed by industry, commerce and cash crop sector. It concerns also the government labor force which includes also public institutions.

### 2.3.1 The Harris Todaro Migration Model :

The main assumption of the Harris-Todaro model is that the workers migration decision depends on their expected wage. Hence, considering the fact that the rural sectors provides employment at a wage  $W_{rur}$ , the worker will chose to move to the urban area when the income he could expect there is higher than  $W_{rur}$ . But the urban expected income depends highly on the probability for the migrant to find a job in the modern sector. The probability to join the modern sector can be evaluated as the proportion of urban population that have a job in the modern sector:

$$L_{mod}/(L_{tot}-L_{rur})$$

where  $L_{tot}$  is the total number of workers in the population,  
 $L_{rur}$  is the number of jobs provided by the rural activities,

$L_{mod}$  is the number of employees of the modern sector.

Then, migration will occur as long as the following condition is satisfied :

$$W_{rur} < L_{mod}/(L_{tot}-L_{rur}).W_{mod}.$$

Hence, the equilibrium situation implies :

$$W_{rur} = L_{mod}/(L_{tot}-L_{rur}).W_{mod}.$$

### 2.3.2 The Present Modeling of the Labor Market

In our framework, the description of the labor market keeps the crucial assumption that justifies the migration. But, in order to make it more realistic, the process includes an additional assumption.

Considering the fact that the informal sector absorbs the unemployed workers, this sector can be considered as an alternative to finding a job in the modern sector. Hence, the expected income for the workers who leaves their agricultural job became :

$$\frac{L_{mod}}{L_{tot} - L_{rur}} : W_{mod} + \frac{L_{tot} - L_{rur} - L_{mod}}{L_{tot} - L_{rur}} : W_{inf}$$

and the condition under which the migration occurs became :

$$W_{rur} \hat{=} \frac{L_{mod}}{L_{tot} - L_{rur}} : W_{mod} + \frac{L_{tot} - L_{rur} - L_{mod}}{L_{tot} - L_{rur}} : W_{inf}$$

where  $W_{inf}$  represented the wage in the informal sector.

Hence, the equilibrium condition becomes :

$$W_{rur} = \frac{L_{mod}}{L_{tot} - L_{rur}} : W_{mod} + \frac{L_{tot} - L_{rur} - L_{mod}}{L_{tot} - L_{rur}} : W_{inf}$$

For the producers, the labor demand follows from the maximization program of firms that gives the optimal production level.

In equilibrium, the wages equal the marginal productivity of labor and supply equals demand on each markets. A full employment situation occurs.

## 2.4 The Households :

The households income is coming from labor income, part of the returns to capital (distributed profits) and government transfers. They are paying taxes on wages at an exogenous rate.

The model assumes that the households are receiving some transfers from outside. In fact, the ECOSIT analysis of households accounts reveals a net positive transfer that is balancing their budget. It is possible to consider this kind of transfer as revenue from family living outside. The informal trade of import goods (principally brought back from the pilgrimage to Mecca) can also justify the amount observed. According to the United Nations Programme for Development, this amount represents almost 2.5% of their total income.

This assumption justifies the choice of the equilibrium between resources and consumption in the households account. In fact, without taking into account this transfer, the level of saving would be negative, whereas in our model, saving is equal to zero.

Hence, according to the UNDP survey on households, the propensity to save is an exogenous parameter that is fixed to zero:

$$YDM-CM=0.$$

Nevertheless, the rural households are the producers of the food crop sector. Since this production units are making profits and saving a part of them, the assumption made on saving must be discussed. In fact, the rural household save the part of profit that is not redistributed and invest it as described in the next part. But this saving is already taken into account in the production process of the model and this way is not in contradiction with the assumption made on household behavior. This remark is still valid for the informal sector which produces also profit, saving and investment whereas the individual or familial units producer are part of the household agents.

The households have a Stone-Geary utility function, assuming a Linear Expenditure System. The maximization of their utility gives thus the distribution of consumption :

$$P C_i : C_i = c \min_j : P C_j + p m c_j : C M_j \quad \bar{A} \quad ! \quad \sum_j P C_j : c \min_j \quad 8 \quad i=1, \dots, 4$$

with  $c_{min_i}$  : the minimum consumption of the good  $i$ ,  
with  $\sum_i p_{mc_i} = 1$ .

I assume that the initial structure of consumption gives  $c_{min_i}$  and allows the evaluation of  $p_{mc_i}$  as the proportion of the total consumption allocated to the good  $i$ . This way, each additional amount of income received is devoted to consumption, and distributed across products according to the distribution key system given by  $p_{mc_i}$ .

## 2.5 The Government :

Taxes are collected with a specific rate on :

- wages for households,
- profits and production for firms,
- imports.

I consider that exports are not taxed. In fact, the analysis of reports on government resources reveals an extremely low amount of this kind of tax. The rate I would have to introduce then would be so small that I chose to consider it equal to zero. Hence, the opposite assumption would have complicated the model without bringing enough effect.

Two reasons can be found to explain this empirical observation.

First, the main part of exports is informal. In fact, agricultural exports are essentially made of the livestock of the nomads. During the transhumance, they are leading their cattle through the country. According to the border price, they are selling their product at the frontier. This transaction is thus informal and is not taxed. Many other products are following this example and pass through Chadian borders thanks to corrupt agents, or in a totally informal ways.

Second, the production of cotton grains (named cash crop sector in our model) is completed by public firms and benefits from tax advantages.

This way, the main part of exports is not taxed and this empirical fact justifies the choice made in our framework.

The level of public consumption is exogenous and distributed over sectors according to exogenous fixed proportions. Those exogenous parameters can be modified with the economic policy tested (not presented here).

Foreign aid balances the national account (and is considered as a positive flow from the rest of the world in the social accounting matrix).

Public investment is a crucial element of this study, and is developed in the next part of this paper.

## 2.6 Market Integration :

Considering that Chad is a small open economy with high permeability on its border, it is necessary to study the price formation process (see Ravallion (1986) and Bhagwati and Srinivasan (1973)). More precisely, it is important to check if the country, due to its small size and to the permeability of its frontiers, is in a price taker position in which informal exchanges can regulate markets and spread tensions on prices. In that case, the determination of price would be exogenous and the equilibrium would be achieved through quantity adjustments.

Since, I carried out a thorough econometric study (see Levy (1999)) of regional market integration for the sectors of subsistence crops, informal sector products and industry on the totality of the Chadian border exchange area which includes Cameroon, Nigeria, Central African Republic, and Niger. Nevertheless the lack of data prevents from taking into account Sudan whose border can open a large exchange zone. Distinguishing these three sectors of production, long time series for consumer prices established by the IMF allows a market integration analysis and make it possible to draw conclusions on the nature of the equilibrium for each sector.

The results attest the independence of both subsistence crop and informal markets from external influence. Nevertheless, they show very clearly the perfect short run integration of the Chadian industrial market with Cameroon and Nigeria. Those assumptions are included in the theoretical framework of the model : the determination of price on industrial market becomes exogenous and the equilibrium is reached by quantity adjustment.

## 2.7 Foreign Trade

The prices of exports and imports are exogenous in foreign currency but their level on national markets depend on the exchange rate and on the taxation rates :

$$PM_i = \overline{P} \overline{W} M_i : (1 + tm_i) : \bar{e}$$

$$PE_i = \frac{\overline{P} \overline{W} E_i : \bar{e}}{(1 + te_i)}$$

### 2.7.1 Imports

<sup>2</sup>Considering the result of the econometric study on market integration, I assume that the demand for the domestic production of agricultural good  $DD_1$  is governed by an Armington function :

$$Q_1 = B_1^m : \pm_1 : M_1^{i \frac{1}{2}} + (1 - \pm_1) : DD_1^{i \frac{1}{2}} : i^{\frac{1}{2}}$$

In fact, imports are imperfect substitutes to national production, so that the share of domestic products consumed by the agents depends on the relative prices (see Armington (1979)).

The first order condition for the utility maximization concerning this kind of goods gives :

$$\frac{M_1}{DD_1} = \frac{P_{D_1}}{P_{M_1}} : i^{\frac{1}{2} m_1} : \frac{\pm_1}{1 - \pm_1} \quad \text{with } \frac{1}{2} m_1 = \frac{1}{2} \frac{1}{1 - \pm_1}$$

with  $P_{D_1}$  domestic price for good 1 and  $P_{M_1}$  price of imported substitute for  $i$  on the national market.

Hence, the elasticity of substitution between domestic and foreign goods increases with  $\frac{1}{2} m_1$ . This way, when this parameter is different from zero, an increase in the relative prices induces a change in the ratio of  $M_1$  and  $DD_1$ . The higher the parameter is, the higher the induced change will be.

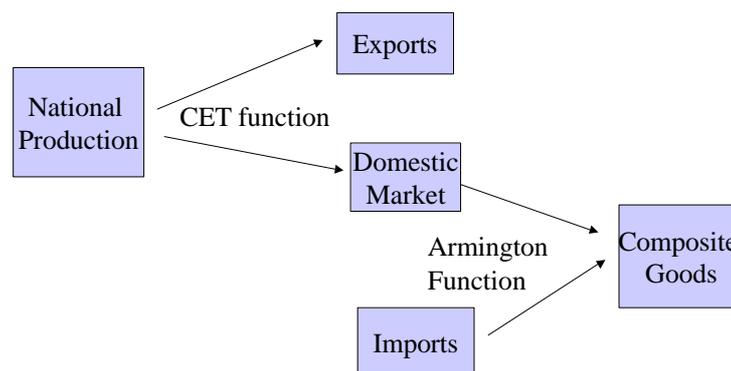


Figure 1 : Functioning of agricultural trade

<sup>2</sup>According to the econometric result, I assume that the industrial price is exogenous. The corresponding quantity of good supplies from the national producers  $DD_2$  is derived from their profit maximization conditions. As long as this quantity is not sufficient to satisfy total demand  $Q_2$ , a quantity  $M_2$  of industrial products will be imported in order to balance  $Q_2$  :  $DD_2 + M_2 = Q_2$ .

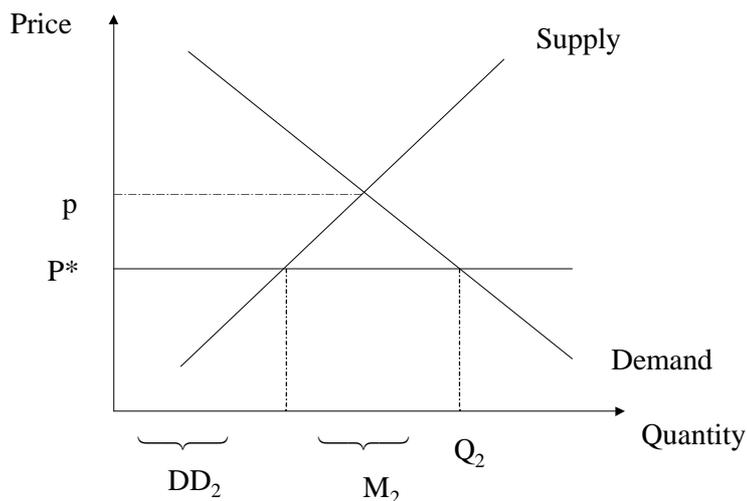


Figure 2 : Industrial market functioning

<sup>2</sup> Concerning the informal sector, I observe that domestic production is only sold on the domestic market, so that there is no import for this kind of good. This way there is no composite good but national supply balances the demand of all agents :

$$DS_3 = DD_3 = Q_3$$

<sup>2</sup>There is no domestic demand for the cash crop production that is totally exported.

In the same way, the commerce sector is allowing the exchanges across markets. Since those services are already dealt with the price system (as will be described below), demand and supply for this product remain implicit.

### 2.7.2 Exports

All sectors export their products (except commerce, left out of this kind of exchanges). The foreign price at which the national good can be sold is

exogenous. Hence, the producer faces the choice of the quantity he can offer to each market : the foreign one has an exogenous price whereas the price on the national market depends on the quantity that will be exchanged. Hence the split of the product between the national and foreign markets will depend on the following Constant Elasticity of Transformation function (CET) :

$$X_i = B_i^e [\alpha_i EX_i^i + (1 - \alpha_i) DS_i^i]^{\frac{1}{1-e}}$$

The first order condition gives the relative share of export and domestic supply :

$$\frac{EX_i}{DS_i} = \frac{\alpha_i}{1 - \alpha_i} \left( \frac{P_{e_i}}{P_{d_i}} \right)^{\frac{1}{1-e}}$$

with  $\frac{1}{1-e} = \frac{1}{1-\frac{1}{\sigma_i}}$ .

## 2.8 Equilibrium

Equilibrium on the market for goods and services implies that the demand for domestic products equals the supply :

$$DS_i = DD_i \quad \forall i = 1, \dots, 4$$

and that each part of the total demand for the composite good satisfies :

$$Q_i = C_i + CG_i + CI_i + I_i \quad \forall i = 1, \dots, 4$$

This demand is satisfied by national production and imports in proportions that depend on the relative prices. In fact, the framework of the model shows how relative prices and wages determine the demand and the supply of each type of good. Equilibrium of goods and production factor markets is achieved through prices adjustments. This way, it is clear that only relative prices influence the exchange levels. Considering the membership of Chad to the Cfa zone, I have chosen to fix the exchange rate to one such that each good could be considered as evaluated in foreign currencies :

$$e = 1:$$

In order to be realistic, there is no access to credit. And since there is no capital market in this model there are neither interest rate nor financial agent in the SAM. Government saving is used to finance public investment. Profits of the private sector are shared between transfer to household and investments in exogenous fixed proportions. Hence, the non redistributed profits are invested.

The current balance is equal to the sum of transfers between Chad and the rest of the world :

$$BC = \sum_i P_i \overline{P} W M_i : M_i \quad \sum_i P_i \overline{P} W E_i : E X_i \quad F$$

where F is the sum of the transfers from the rest of the world (foreign aid, oil revenue and transfer to households). F is exogenous but the oil boom shock affects its value in the simulation presented next.

Since I fix the exchange rate e to 1, this model is defined by 18 times 5+8 equations and 18 times 5+7 endogenous variables. According to Walras law, this system may not be independent and its resolution implies to drop one equation in order to make the system independent (and presenting the same number of equations and variables).

I chose to suppress the investment function and to consider that the total amount of saving is dedicated to investment.

Hence investment is equal to the total amount of saving collected and does not depend on demand functions linked with the private or public needs.

Nevertheless, the public investment choice will be analyzed in the various simulations described below. Its impact on household and on rural development will be the subject of the present work.

### 3 PUBLIC INVESTMENT RETURN AND ENDOGENOUS GROWTH

#### 3.1 The Simulation Analysis : the Impact of Public Choice

The oil boom expected in Chad in the coming years will generate a substantial annual income for the government. Its amount is estimated to be

equivalent to the current international aid flow received each year. This positive shock in the government budget will allow different allocation choices. We already know that this oil revenue will be the only direct consequence of oil exploitation in the short run. In fact, a pipeline will join the extraction site to the harbor of Kribbi in Cameroon and the total quantity of oil extracted will be sold outside the country. All the output will be sold externally and not a barrel will belong to Chad. Almost no job will be given to local workers. The negotiations concerning the conditions of the oil exploitation was complex and protracted<sup>2</sup>, and Chad won't be the owner of the resources but will only receive an annual royalty.

Since this income can be considered as the only economic direct consequence of the oil exploitation, not all the usual characteristics of a trade boom are pertinent in this case : while the spending effect is likely to occur, the resource displacement effect is no more verified here (Corden and Neary,1982). Hence, the modeling of the oil boom presented here is very simple.

Nevertheless, the government will face a dilemma concerning the use of this substantial income. The situation of the infrastructure and the differences between the North and South production environments are discussed in the introduction. The lack of roads and the agricultural development potential justify clearly the need of public investment in Chad.

As explained in the next section, public investment can offer substantial growth opportunities to a developing country.

Thus, the CGE model presented in section 2 offers the possibility to estimate the impact of different kinds of public investment and to compare their effects on household incomes and on rural development.

In order to be realistic, only half of the oil revenue is assumed to be employed in the policies simulated in the different scenarios presented here. Because of the high level of uncertainty about the government behavior, the rest of this national income can be considered as lost for the economy. Hence, when oil revenue is mentioned in this analyze, its amount corresponds to half the royalties effectively received by the Chadian government.

In order to appraise the relevance of investment as a use of oil revenue, I present here a benchmark scenario (named scenario1) in which the government decides to distribute subsidies to households. In other words, the households receive half the oil revenue. Corresponding to 6% of their total

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<sup>2</sup>in fact Cameroon benefits are almost equivalent to Chadian oil revenue

income, this new revenue is directly devoted to consumption according to the assumption made in the model. In fact, the increase in the level of Household demand for goods and services induces an important increase in imports and a substantial rise in the price index. In this case, no growth can occur and the trade balance deteriorates.

Table 1 : Aggregate results from simulation of subsidies distribution  
( in percentage changes from base value)

GNP vol.	House. Cons.	Tot. real wages	Rural real wages	Price index
0%	8.41%	0%	5%	4.5%

Agr Prod.	Cotton Prod.	Industr. Prod.	Inform. Prod.	Comm. Prod.
0%	-19%	-1%	1%	2%

### 3.2 References to Empirical Studies

The impact of public investment on productivity and growth has been largely discussed in recent years by empirical studies and theoretical work. This question is crucial since it helps to measure the effects of policy choice and allows the assessment of sustainable development policy. It is also helpful for government and international organizations who decide on public expenditures.

In addition to the work of Barro and Sala-I-Martin on endogenous growth, four papers discuss these precise points in an empirical way and provide a basis on which to found the assumptions made about the public investment returns.

<sup>2</sup>Ashauer (1989) studies the returns of public investments in infrastructures and their impact on the productivity slowdown which occurred in the United States between 1970 and 1985. He shows that public capital was then more efficient than private capital in terms of growth. Moreover, according to his empirical tests, this kind of public expenditure can improve the productivity of the private sector.

This explains how the lack of infrastructure spending in the United States during this period induced the slowdown of productivity observed then.

<sup>2</sup>Binswanger, Khandker and Rosenzweig (1993) distinguish different kinds of public investment. Two of them are particularly relevant in the present case : road building and irrigation systems. On the one hand, public spending in irrigation has a direct effect because it improves the productivity of the agricultural sector. On the other hand, investment in infrastructure such as roads offers opportunities to farmers to have access to markets and reduces the cost of all kinds of transactions. In fact, both affect agricultural output and therefore must be considered as a crucial growth factor for the food crop sector and rural development. In this way, public investment should be considered as a policy tool definitely comparable to targeting credit access or price regulation.

<sup>2</sup> Based on panel data concerning India, Mitra, Varoudakis and Végonzès (1998) point out the impact of infrastructures on productivity growth and technical efficiency in the manufacturing sector. Considering different proxies of infrastructure levels in various regions, they show how the lack of infrastructure can limit growth in a developing country. Total factor productivity (TFP) is clearly affected by a low level of infrastructure. Hence, for identical quantities of input, output varies according to the level of infrastructure of the corresponding regions.

<sup>2</sup>The analysis of Herrera and Dessus (1996) deals with the econometric aspect of the preceding questions. They choose to test the role of public capital for economic growth in 28 developing countries during the 80's. The positive impact of public capital on long-run growth is underlined and thus explains to what extent investment in infrastructure can improve the productivity of the private sector. The criticisms of some previous work (Ashauer for example) concern the bias in estimations due to common trends for the variables used, stationnarity in long term series or the weak realism of the elasticity estimation for public capital. These arguments are resolved by the econometric method used by Herrera and Dessus. The elasticity of public capital with respect to national product is evaluated at 0.2. But contrary to Ashauer's result, the elasticity of private capital seems to be higher than that of public capital in the case of a developing country.

Nevertheless, the elasticity of public investment is positive and high in each empirical study. Its value falls in a range between 20% and 70%.

All these analytical work clearly points out how crucial public investment in infrastructure is for the economic growth. It presents this kind of public expenditures as an obvious tool for improving factor productivity and an unavoidable complement of private capital. Moreover, the lack of it is often

considered as responsible for insufficient or declining economic growth for both developed and developing countries.

### 3.3 Infrastructure and Roads : an Endogenous Growth Process

Building roads linking the South and the North of the country seems essential in the case of Chad for two main reasons. First, crop production in the South is often in surplus whereas famines occur regularly in the Center of the country. The lack of practical roads linking these regions prevents the distribution of product through the country. Each rainy season seriously damages the bush tracks and it sometimes takes a week to reach the South from N'Djamena. The restoration of dirt tracks can sometimes block up the passage of vehicles for many days.

The extremely high cost of transportation isolates regions and hinders the functioning of the market. The references detailed above clearly show the relevance of infrastructure investments in such situations. They indeed allow one to expect a significant economic growth effect if appropriate measures are taken.

Secondly, the household's welfare suffers greatly from the lack of infrastructure when access to health center, hospital<sup>3</sup>, water and electricity, roads or telecommunications are as underdeveloped as in Chad<sup>4</sup>.

In the first scenario simulating public decision, I choose to affect half the amount of oil revenue to the construction of infrastructure, especially roads. The formalization included in the model is the following :

$$X_i = TPT : A_i : \theta_i : L_i^{\frac{\alpha_i - 1}{\alpha_i}} + (1 - \theta_i) K_i^{\frac{\alpha_i - 1}{\alpha_i}}$$

with  $TPT = \frac{1}{\alpha_i} (IG + GINV)^{\alpha_i}$ .

where IG is the initial level of public capital stock and GINV the growth rate of IG.

The level of public capital stock is introduced as a production factor and can thus be compared to a technical progress indicator. Hence, when road or electricity enters in the production process, the productivity of factors  $K_i$

<sup>3</sup> there is only one hospital in the country

<sup>4</sup> for more details and descriptive statistics see the working paper report on economic situation and development potential in Chad (Levy, 1998).

(private capital) and  $L_i$  (labor) is improved. An endogenous growth process occurs and I analyze its effects using the CGE model.

The value of  $\delta$  is fixed in such a way that since no new investment is engaged, the level of TPT is equal to one. Then, when the oil revenue is affected to public capital, the level of TPT increases from 1 to  $(GINV)^1$ .

Table 2 : Aggregate results from simulation of infrastructure improvement ( in percentage changes from base value)

GNP vol.	House. Cons.	Tot. real wages	Rural real wages	Price index
7.9%	8.4%	8.46%	12.16%	5.37%

Agr Prod.	Cotton Prod.	Industr. Prod.	Inform. Prod.	Comm. Prod.
19%	63.9%	26.8%	5.9%	26.6%

The simulation results are the following :

-the output of all the sectors improves because of the technical progress affecting the productivity of their production factors ;

-since agricultural and informal sectors are paying labor its marginal productivity, the wages rise and the demands fall. On the contrary, the demand for labor of the modern sector rises because the marginal productivity of labor grows whereas the wage rate stays constant. In fact, the latter is fixed in this sector whereas in the two others it is not. Migration stops, since the modern sectors output is also constrained by demand. Hence, the workers join the modern sector ;

-in this way, the rise in wages in the informal and agricultural sectors and the new demand for labor in the modern sector increases the wage bill. Thus, household income improves, as does their demand for goods. Household consumption is rising by 14.13 % ;

-since industrial prices are assumed exogenous, inflation is limited in a certain way.

It is possible to conclude that this kind of policy prevents the economy from suffering from the Dutch disease and reduces the food aid dependence of the country. Moreover, household welfare must be largely improved by this kind of infrastructure which, because of its extremely high cost, can only be

undertaken by the government. This type of improvement normally benefits every citizen, unless the government chooses to target certain beneficiaries.

Despite the fact that this kind of policy requires a long-term commitment by the government, it presents the advantage that its returns last over time.

### 3.4 Irrigation System and Agricultural Development

The characteristics of the agricultural sector differ greatly among Chadian regions, and the Chadian territory can be divided into three climate zones.

¶The north is desert : its area is almost equivalent to France, its population is essentially nomading, living from trade and livestock breeding. During the transhumance, they lead their cattle through the country. There is no agricultural production and extremely poor access to water.

¶In the center of the country (Chari Baguirmi, Guera and Salamat region), households often suffer from famine. Rainfalls are low but water tables and flood plains (Ouadis) provide additional source of water. The capital stock in the agricultural sector is very low.

¶The southern regions benefit from a high rainfall and generate a crop production largely in surplus. The climate, semi-humid tropical, and the rivers (of which the Chari) allows easy access to water.

Whereas the crop production in the South can, in some years, be sufficient to feed the whole Chadian population, famines in the rest of the country are endemic and the food crop deficit can, in some years, reach the level of 200,000 tons of grain (i.e. more than 10% of the Chadian production).

Nevertheless, the agricultural sector has a substantial potential for development. In fact, only 1% of the arable land is irrigated and water resources exist but need to be exploited. Hence, the low capital intensity of the food crop sector justifies the need for investment improving the existing irrigation system.

Considering that public capital is an imperfect substitute to private capital, I define the level of total capital engaged in the agricultural sector as a composite good made of private and public capital :

$$K_t = A_k \left[ \alpha_k K_{pv}^{\frac{\alpha_k-1}{\alpha_k}} + (1-\alpha_k) K_{pb}^{\frac{\alpha_k-1}{\alpha_k}} \right]^{\frac{\alpha_k}{\alpha_k-1}}$$

with  $K_t$  : total capital stock,

$K_{pb}$  : public capital stock,

$K_{pv}$  : private capital stock.

Hence, the agricultural production is :

$$X_1 = A_1 \cdot \left( \frac{1}{\sigma_1} LD_1^{\frac{\sigma_1-1}{\sigma_1}} + (1 - \frac{1}{\sigma_1}) K T_1^{\frac{\sigma_1-1}{\sigma_1}} \right)^{\frac{\sigma_1}{\sigma_1-1}}$$

with  $LD_1$  : labor demand for the agricultural sector,

$KT_i$  : total capital stock in the same sector,

$\sigma_i$  : substitution elasticity between labor and capital for the sector

Each public investment in agriculture is financed by the oil revenue such that the government budget remains balanced. The new capital engaged is an imperfect substitute to private capital but still affects the amount of total capital engaged in the production process of the sector.

The effect of this measure is given by the simulation of the CGE model.

Table 3 : Aggregate results from simulation of irrigation system improvement ( in percentage changes from base value)

GNP vol.	House. Cons.	Tot. real wages	Rural real wages	Price index
14.7%	16.6%	16.6%	27.6%	9.3%

Agr Prod.	Cotton Prod.	Industr. Prod.	Inform. Prod.	Comm. Prod.
6.4%	9.1%	0.4%	-6.0%	3.7%

The process is the following :

-the new amount of capital stock in the agricultural sector induces some labor substitution, but also an increase in output. Thus the price of agricultural goods decreases ;

-the cash crop sector benefits from this decrease because its main intermediate input are coming from the primary sector. Hence, this sector's unit profit increases as does its output, which is exported ;

-the commerce sector consequently grows because of the new quantity of goods for sale on national and foreign markets ;

- hence, workers are migrating to the modern sector (more precisely to cash crop and commerce sectors). The flow of migrants is essentially composed of workers coming from the informal sector but, also of farmers no longer employed in the rural sector ;
- the increase in labor productivity in both the rural and informal sectors entails an increase in wages, whereas the labor demand rises in the modern sector : the wage bill grows by more than 16.6 % ;
- the real income of rural households improves (27.6%) whereas total household consumption increases by 16.5%.

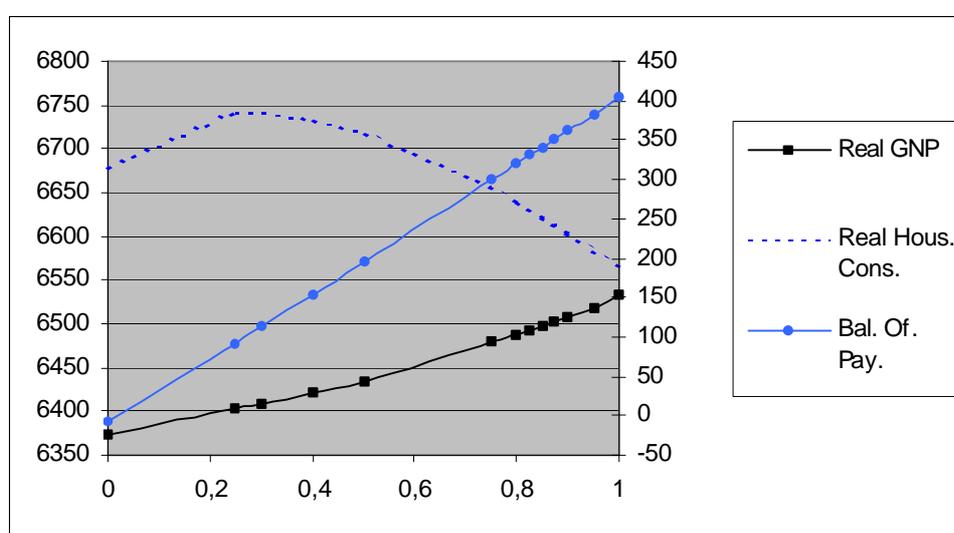
It is now possible to underline the implications of this policy choice. First, rural households benefit most from this measure since their income improves by 27.6%. Secondly, the capital stock of the agricultural sector is increased so that this sector will benefit from a productivity improvement in the coming years. Agricultural sector growth will go on in the following years. This result is particularly interesting in a country highly dependent on food aid. Third, the growth of national product is much higher in this scenario than in the previous one (which corresponds to the traditional development policies suggested by Chad development partners). In fact the lower level of imports improves the trade balance and economic growth (which is multiplied by two relative to the reference period).

Hence, the agricultural development potential should be taken into account since it offers a relevant alternative to traditional policies and prevents an unbalanced development trends between urban and rural households.

### 3.5 The Complementarity of Investments

The comparison of different kind of public spending confirms the relevance of public investments. The results of the simulations concerning roads infrastructure and irrigation allow to evaluate their respective impacts on various economic indicators. Hence, we are now able to compare these two polar cases of public decision and to understand their particular advantages in term of growth, rural development or household welfare improvement. Nevertheless, the complementarity of these measures has to be tested. In fact, a combination of these investments can generate a higher effect than the two extreme choices tested above in which half of the oil revenue is entirely dedicated to one kind of infrastructure.

Assuming that  $\theta$  is the share of public investment devoted to irrigation,  $(1-\theta)$  will be the share of this amount dedicated to road. The two scenarios considered above correspond to  $\theta = 0$  when the whole public investment is devoted to road infrastructure, and  $\theta = 1$  when it is all dedicated to irrigation. Hence, we can evaluate the impact of these measures for each value of  $\theta$  between 0 and 1. In other terms, we can draw the curve linking the two particular levels of economic indicators obtained before (corresponding to  $\theta = 1$  or  $\theta = 0$ ).



(note : the right-hand scale is for balance of payment)

Figure 3 : Evolution of the GNP and its components according to the value of  $\theta$

According to the results of these simulations, we can conclude that GNP growth is constantly increasing with the share of public investment devoted to agriculture.

The evolution of the GNP is especially due to the evolution of foreign trade whereas the role of ...nal consumption seems much lower. More precisely, the level of imports is growing with the share of investment devoted to infrastructure. This can be explained by the needs to import which grows

with the level of intermediate consumption. In fact, the growth of the modern sector (which is a decreasing function of  $\textcircled{R}$ ) implies the import of many kinds of goods, which are not produced by the Chadian economy. The modernization of the economy induces a higher dependence on foreign trade, whereas the development of the agricultural sector is more autonomous. This increasing amount of industrial products is not balanced by the growth in exports due to the increase in competitiveness of Chadian production.

Table 4 : Aggregate results on trade from simulations  
( in percentage changes from base value)

	Agr Export	Cotton Export	Industr. Export	Informal Export
$\textcircled{R} = 0$	25.6%	63.9%	26.8%	-2%
$\textcircled{R} = 1$	8.6%	9.1%	0%	-26%

	Agr. Import	Industr. Import	Bal. of payment (Million cfa)
$\textcircled{R} = 0$	9.2%	42%	-11.28
$\textcircled{R} = 1$	3%	4%	404

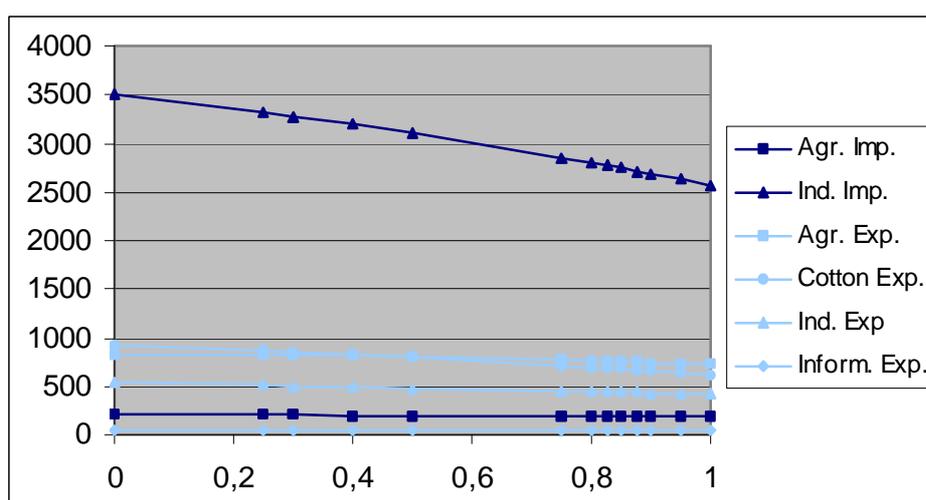
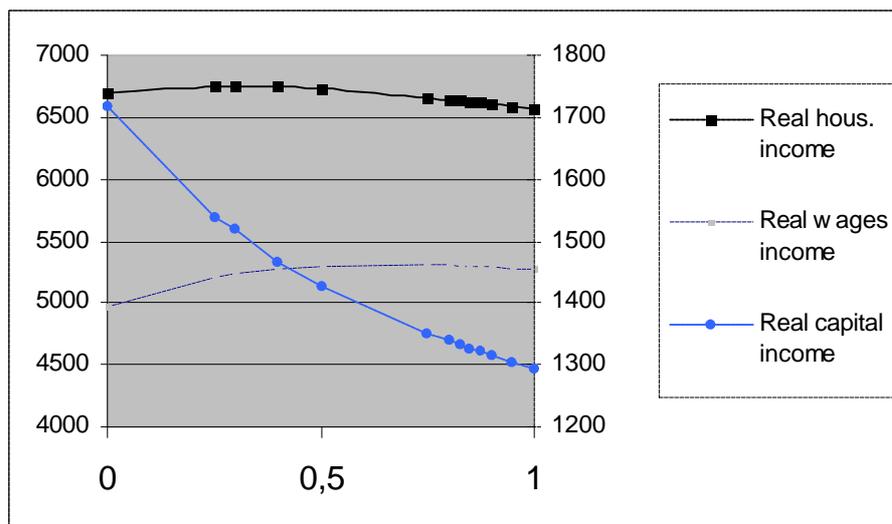


Figure 4 : Evolution of trade's components according to the value of  $\theta$

Two particular points have to be noticed in order to understand the evolution of ...nal consumption :

- the ...rst element of ...nal consumption is government consumption which is exogenous and does not depend on the value of  $\theta$ .
- the other element is households consumption, the amount of which corresponds exactly to their income because of the assumption made on households saving.

Hence, in order to explain how the value of  $\theta$  influences the level of ...nal consumption, the evolution of the components of households income has to be detailed.



(note : the right-hand scale is for real capital income)

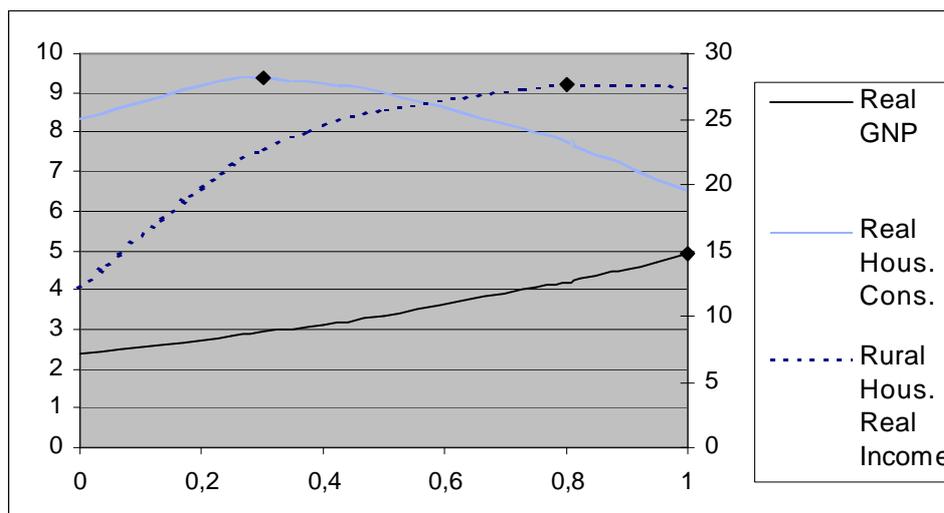
Figure 5 : Evolution of household's income and its component according to the value of  $\theta$

The variation of the households consumption is small. The level of this consumption is higher in scenario 1 than in scenario 2, and the distribution

of public investment that entails the higher level of increase for households income correspond to  $\theta=0.3$ .

The share of profit in households income is mainly responsible for this evolution. Since the profit sharing rate is exogenous, we can observe that the share of public investment devoted to irrigation reduces the total level of profit. The increase in prices (linked to  $\theta$ ) is causing the higher cost of intermediate consumptions. Moreover the total sum of wages reduces the profit made by the firms. These two elements explain the evolution of the households income.

The distribution of incomes among households differs a lot between the policies undertaken. Whereas the increase in rural wages improves the welfare of the poorest part of the population, capital income reduces the income of the richest households. Nevertheless, the value of  $\theta$  that entails the higher level of the household's income (and consumption) corresponds to a development policy which includes irrigation improvement.



(note : the right-hand scale is for rural households real income)

Figure 6 : Evolution of the main economic indicators according to  $\theta$  (the maximum for each is indicated with a black point)

These results confirm that agriculture should be included in the Chadian development program whatever the choice of the economic indicator.

### 3.6 The Robustness of the Results

Since the values of some parameters are not based on my own econometric study but inspired of other CGE models, it is important to test the robustness of the results presented here. I change the value of each kind of parameters and I control if the change in the simulation outcome(see the appendix) :

-changes in the value of trade function parameters do not affect the results of the two scenario (see the appendix),

- the impact of the scenario 1 and 2 can be reduced by the choice of the parameter  $\frac{3}{4}_i$ <sup>5</sup> for the agricultural and industrial sector. In fact, this choice can affect the number of migrating workers. Nevertheless, the hierarchy between scenario 1 and 2 is the same whatever the economic indicator,

- concerning the agricultural sector, the results are all the more confirmed that public and private capital are substitute.

-the value of the technical progress function parameter(<sup>1</sup>) has been justified in the previous section and chosen below the mean of the econometric references results. Hence, for  $\beta = 0.4$  (instead of 0.3) the real GNP and the rural households income are higher but still below their value in the scenario 2.

We can conclude that only very low value of  $\frac{3}{4}_i$  for the agricultural or industrial sector can reduce the results on economic growth but do not reverse the conclusion of this study.

### 3.7 CONCLUSION

The aim of this study is to suggest different uses of the oil revenue the Chadian government will receive over the ten years to come. Thanks to a CGE Model it is possible to evaluate different kinds of development policies. Taking place in the classical tradition, the present CGE model's assumptions take into account the market integration of the industrial sector as well as other assumptions relevant to the case of Chad.

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<sup>5</sup> $\frac{3}{4}_i$  is the elasticity of substitution between capital and labor in the production function of the sector i.

The kinds of investments studied here concern irrigation systems and roads infrastructure. In fact, considering the economic potential of agriculture as well as the high level of Chadian dependence on food aid, the lack of this kind of infrastructure is a crucial impediment to growth.

In both cases, it is possible to analyze the effect of each measure on the main economic indicators, and more precisely on the Chadian dependence on aid and food assistance. The simulations show how irrigation can generate a rate of economic growth much higher than that induced by the improvement in typical public infrastructure as it is traditionally suggested. Further more, this water management policy targets especially the poorest part of the population (employed in informal and rural sectors) whose income increased by 27.6 % in one year.

Then I analyze the complementarity of these two kinds of investment in order to suggest what part of the oil revenue should be dedicated to the agricultural sector according to the objective function of the Chadian government. Considering that each kind of investment presents particular advantages in term of growth and household welfare, it is possible to discuss what kind of policy should be adopted according to the importance given to rural household welfare. The improvement of water access in the rural sector prevents the gap between rural and urban areas from growing, reduce the Chadian dependence on food aid and entails a growth in rural household consumption of more than 30% for the ...rst period of the shock.

In addition to the household consumption's growth, production conditions are improved and will continue to affect the economy over the following years. In fact, this result points out the effect of the measure for the ...rst year of oil boom. But these new investments increase the capital stock or the technical progress level for many years. Moreover, if the public investments are repeated during the oil boom period, the effects will increase and a sustainable growth process will be engaged.

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## 5 APPENDIX