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DEVELOPMENT STRATEGY AND GOVERNANCE DIVISION

June 2006

DSGD Discussion Paper No. 35

Public Investment to Reverse Dutch Disease: The Case of Chad

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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Tables

Figures

ABSTRACT

This paper studies the relevance of agricultural policies for avoiding Dutch Disease, which affects many less developed countries experiencing a resource boom. Using a computable general equilibrium model calibrated for Chad, we study the impact of using this country's annual oil revenue for public investment, particularly in the development of road and irrigation infrastructure. Our model takes into account the integration of markets and migration processes. We find that improving water access would reduce Chad's dependence on food aid and entail a substantial improvement in rural household welfare.

J.E.L classifcation: O110, O130, Q18

PUBLIC INVESTMENT TO REVERSE DUTCH DISEASE: THE CASE OF CHAD

Stephanie Levy [1]

I. INTRODUCTION

A country beginning to exploit a rare natural resource, such as gas or oil, experiences large inflows of foreign currencies. One might expect this new income to generate economic growth and even reduce poverty, especially when such new sources of income occur in developing economies. The theoretical foundations for this intuition appear as early as Sir Arthur Lewis (1955), who argues that such resources allow for new investments, spurring economic growth. Rosenstein-Rodan (1943) or Murphy, Shleifer and Vishny (1989) also explain that poorer countries need such a 'big push' to escape the poverty trap.

However, the historical and modern evidence suggests that such a massive inflow of foreign currency can have adverse economic effects. Indeed, many countries experienced severe recessions and poverty increases when they started exploiting natural resources. External trade booms often entail economic instability, generally accompanied by trade balance and budgetary deficits, leading to a worse rather than better economic situation. Auty (2001) shows that between 1960 and 1990 income per capita has grown much faster in developing countries that were not natural resources exporters and that sharper economic decline occurred in mineral products producing countries. The economic syndrome associated with these trade shocks, Dutch Disease[2] , is characterized by an increase in the real exchange rate as well as the contraction of some sectors[3] due to

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[2] Corden and Neary (1982) coined this term in reference to the Netherlands who experienced an increase in their real exchange rate and decline in their manufacturing sector when they started exploiting their gas reserves.

[3] Corden and Neary (1982) anticipate that the tradable sector should decline due to the increase in the real exchange rate. However, Benjamin et al. (1986) or Gelb (1986) reject this result, arguing that the non-

the loss in competitiveness. Our paper analyzes how these negative effects can be countered by appropriate investments. To illustrate how good management of oil revenues can generate growth and reduce poverty, we present a quantitative analysis of the possible impact of the oil boom in Chad, a very poor African country, which began exploiting its oil resources in 2004.

Chad is among the poorest countries in the world. The United Nations Development Programme (UNDP) ranks Chad 164th out of 175 countries according to the Human Development Indicator. Three quarters of its population live below the poverty line. With a GNP per capita below $230, less than half of the average in Sub Saharan Africa, the country is highly dependent on foreign aid. Famines are frequent and endemic in the Centre and in the North. However, according to Chad's development partners and as this paper argues, the primary sector presents considerable development potential (World Bank 1997a and b). Moreover, the substantial oil income offers new opportunities for investment and poverty reduction. Over the first 20 years of exploitation, its average annual amount is forecasted to be about $ 80 million, which is equivalent to the current annual international aid flow or to Chad's budgetary revenue. Furthermore, the country had benefited from a historical agreement with the World Bank and the Oil Consortium. While oil reserves of approximately 900 millions barrels were discovered in 1969 in the South, the project of exploitation was agreed only in 2001,[4] with the World Bank acceptance to finance the Chadian and the Cameroonian parts of the project. The World Bank's participation was mainly to secure the large investment engaged by the oil companies ($ 3.5 billion), in return, Chad had agreed to use the oil revenue to finance social programs and develop infrastructure provisions.

What can we then expect for the future of Chad? To evaluate the effects of different possible uses of Chad's oil revenue over the coming years, we use a

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tradable sectors might rather be the ones affected. These papers respectively argue that Corden and Neary theoretical framework did neither take into account trade determinants for an open economy nor the behavior of the government which might either decide to use or waste the windfall.

[4] The political risk was considered high in a country devastated by 20 years of civil wars and the consortium has changed several times.

Computable General Equilibrium model (CGE)[5], which allows for a quantitative macroeconomic analysis. Since such models belong to the class of simulation tools, they are particularly helpful for understanding the mechanisms and the stakes of policy choice. The parameters are calibrated for a given year. Their values are thus not based on econometric work, which would require long time series, unavailable for Chad. Though advantageous for developing countries-since it does not require long time series-this tool does not allow forecasting, unlike econometric models.

Our CGE model is similar to those in Dervis, DeMelo and Robinson (1982) and Collange and Calipel (1993). Following their "neoclassical structuralist approach", this model represents an open economy with a fixed exchange rate. However it takes into account several specificities of the Chadian economy. First, the model allows for migration of workers, as it is a major component of the Chadian labor market (World Bank 1997b). Second, our model accounts for the high rate of penetration of industrial markets and therefore provides a particular approach to the price formation mechanism for each sector. For this purpose, we conduct an econometric study of regional market integration for the sectors of subsistence crops, informal products and industry on the whole Chadian cross border exchange area. The aim is to check whether Chad's small size and border permeability implies exogenous prices on some markets, by which the equilibrium would be achieved through quantity adjustments. This econometric study proves the short run integration of the manufacturing sector.

Based on the UNDP's household and informal sector survey (ECOSIT) and its extrapolation at the national level, the social accounting matrix reflects some other specificities of Chad's economy, such as household saving and consumption behavior. This dataset also allows us to assess some of its informal components such as the nature and real value of imports that are heavily underestimated in official statistics.

[5] This type of model was initially developed by the World Bank and is now broadly used and applied to many developing countries. Adelman and Robinson (1978) constructed the first model for Korea which became a reference for various models simulating the impact of economic policy on income distribution.

Concerning the simulation of the oil boom, we make the assumption that the oil revenue is the only direct impact of oil exploitation in the short run. As in Benjamin et al.'s (1986) study of Cameroon's oil boom, this assumption is appropriate to the case of Chad. In fact, a pipeline will connect the extraction site to the harbor of Kribbi in Cameroon and all the extracted oil will be exported. Chad will not own any of the oil but will instead receive an annual royalty. Our simulations aim to evaluate the effects of different possible uses of this oil revenue.

As uses of oil revenue, we consider two types of investment policies. The first one concerns the development of irrigation and the second the development of the road network. Two aspects of the agricultural sector justify this focus. First, the crop production in some regions in the South and the East are, under favorable pluvial conditions, almost sufficient to feed the whole Chadian population. Unfortunately the lack of roads severely hinders the distribution of agricultural products, which instead are frequently exported to neighboring countries, especially to Cameroon. This clearly reveals the lack of transport infrastructure as a severe impediment to growth. Second, only 1% of the arable area is currently irrigated and the potential for agriculture development is substantial. Until around 2000, famines and access to food used to be mainly distributional and market clearing problems. Since then however, the differential in the growth rate of production and consumption means that annual deficits have become also structural. However the low capital intensity in this sector is a major constraint, while the lack of water is not. Therefore investment in this sector is a crucial issue.

We analyze each policy's effect on the main economic indicators and on the poorest part of the population. Thus, assuming that part of the oil income would be devoted to the development of road or irrigation infrastructures, public expenditures would affect the production functions of the relevant sectors. This policy leads not to the Dutch Disease syndrome but to an increase in the real GDP (up to 14%) and a significant improvement in the income of the poorest part of the population (up to 27%).

Since each type of policy has particular advantages in term of growth and household welfare, we then analyze mixed policies, and discuss the optimal use of oil revenue depending on the weight given to rural household's welfare.

A vast literature studies the economic mechanisms at play during resource booms,[6] but very few is said on how the government should use the windfall. Bevan, Collier, and Gunning (1987, 1989, 1992)[7] and Benjamin (1990) are among the few to do so, but the first papers look at commodities boom in a partial equilibrium framework, while Benjamin considers private investors as recipients of the windfall. Instead we present a general equilibrium approach and a quantitative analysis of how the recipient of the revenue (the government) should use the windfall. Therefore this study illustrates the work of Gelb (1986, 1988), who showed that economic decline and poverty worsening might be due primarily to mismanagement of the revenue and that appropriate public investment could alter the outcome of resource booms. In this view, Ross (2001) explains how inappropriate political decisions can generate low or even negative growth and worsen households' living conditions. This paper adopts the methodology developed by Benjamin et al. (1989) for Cameroon and tests the recommendations of Gelb and Pinto (1987), who compares the Nigerian and Indonesian oil booms, concluding that appropriate public investment and relevant agricultural policies could change the economic impact of the shock.

Section 2 presents the model and the assumptions relevant for Chad. Section 3 presents an empirical assessment of different public investment returns in developing countries. The section then discusses the simulations results and analyzes several public investment policies. Finally, we study the complementarity of public investments and discuss in which measure rural development and growth are affected by diversifying them. Section 4 comments on the different results in the context of both the literature and

[6] See Auty (2001) for a review.

[7] Bevan, Collier, and Gunning recommend waiting until the end of the resource boom to invest. Even though their theory focuses on commodity rather than natural resource booms-which means that households, not the government, receive the windfall- they do not discuss the kind of investment that should be undertaken.

the debate on agriculture in Sub-Saharan Africa. This section also links to the political aspect of resource booms and the risks associated with them. Section 5 concludes that relevant rural policies and significant support to agriculture might be the appropriate answer to resource booms in poor African countries. Such policies might be efficient not only to counter Dutch Disease but also to generate growth and poverty reduction.

II. THE MODEL

The CGE Core

Our model is very similar to IFPRI standard CGE model used to study many African countries (Lofgren et al., 2001). Therefore, we present only those elements, which differ from the standard model, as we specialize it to the economy of Chad. First we test the integration of Chadian markets with those of neighboring countries and use the results to model price determination in every sector. Second, the labor market allows migration of workers according to a process inspired by Harris and Todaro (1970).

Parameters are calibrated using the GAMS software, i.e. they are endogenously determined with iteration processes given the initial referring year, 1996. Nevertheless, the elasticities in the production function and in the trade function remain exogenous. These define the substitutability between domestic goods and imports (Armington function) and between domestic and exported goods (CET function) respectively. We take standard values for trade elasticities, 0.6 for the CET and the Armington functions and 0.6 for the production functions. These values (Table 1) are the same as in some of the applications of the standard IFPRI CGE model for African countries.

Table 1. Elasticities used in the CGE Model

φ_i (CET function exponent)	ρ_i (Armington function exponent)	σ_i (Elasticity of substitution between capital and labor)	**Sk** (Elasticity of substitution between public and private capital in the agricultural sector)
0.6	**0.7**	**0.6**	**0.6**

The closure rules are as follows. The government's account balance is achieved through fixed tax rates and flexible government savings. Chad's currency is pegged with the Euro, therefore we assume an exogenous nominal exchange rate. Foreign savings are assumed flexible and the trade balance is not constrained. This closure rule makes sense in the context of a country that belongs to the Euro monetary zone. In those countries, trade balance deficits are indeed absorbed by the French Central Bank whenever they

occur. In the model, the adjustment to any trade imbalance is therefore made through real exchange rate adjustment (De Melo and Devarajan.1987).

We study an external trade shock, with a focus on Dutch Disease, and that assumption allows for a better understanding of how foreign trade might evolve. The consequences of this choice are twofold. On the one hand, the model will not allow for welfare comparison, although GDP will reflect the differences in trade balance outcomes. On the other hand, this modeling, which is more relevant for a country that belongs to this monetary zone, will allow us to better analyze the impact of the policies we simulate on trade and competitiveness, in particular through a good understanding of the possible change in real exchange rate, which is the central element of Dutch Disease.

The macro-closure is made by the adjustment of the real exchange rate which allows savings to equal investment. Investment is therefore fixed as are the marginal saving propensities. Capital is fully employed and activity-specific. As the following sections explain, the industrial price and the wage in the formal sector are fixed.

Since we focus on public investment and its impact on capital stock and total factor productivity, we want to explain our assumptions on savings and investment mechanisms. Private savings come from profits that are realized in every sector. Even though rural households are the producers in the food crop or informal sector, the survey we use distinguishes between their "production" accounts (which include savings and investment) and their "household" accounts. Therefore, the rural or informal producers (including individual and family units) save a fixed proportion of profit made and invest it. However, the household marginal propensity to save is zero. The fact that Chadian households do not save at the aggregate level reflects the ECOSIT household survey results and is also confirmed by other institutions' statistics such as the Central Bank of Central African Countries and the World Bank. This assumption reflects a Chadian specificity. The ECOSIT even shows negative household savings at an aggregate level, and especially in rural areas, where their aggregate spending largely exceeds their total

income. Even when informal transfers from abroad[8] are accounted for, savings remain negative. The African Development Indicator (World Bank 2001) also allows us to track household budgets in Chad, especially over 1987-1997. This data confirms that over this period, aggregate household consumption exceeds aggregate income. Finally, over1987-1991, income per capita increased by over 50% without inducing any saving at the aggregate level, not even an improvement in the negative saving rate.

The Data and the Social Accounting Matrix

The survey on consumption and informal sector (ECOSIT) was completed by the United Nations Development Programme (UNDP) between June 1995 and June 1996 on a population sample of 2,606 households (UNDP 1998). They were chosen randomly in the largest four cities in Chad and on the rural surroundings of their prefectures. Initiated by the Statistics and Economic Division of the Chadian Ministry of Planning and Cooperation, this survey has been financed and directed by the UNDP. Its originality lies in its focus on both households and their informal activities. More precisely, the ECOSIT focuses on the production and characteristics of the informal activities that households develop to respond to their needs and to accumulate capital. The ECOSIT is the first statistical inquiry related to Chadian households living outside N'Djamena and focusing on non-demographic characteristics. This is also one of the only African surveys with such data on the informal sector. Since it provides measures of informal production, this survey has allowed a complete overhaul of the Chadian national account basis. It helps to take into account a large range of the Chadian Economy, never evaluated before. The previous national account was based on the year 1977. Until ECOSIT, there was scarcely any reliable data allowing an analysis of Chad's economy.

Our social accounting matrix is based on the ECOSIT and the financial statistics published by the Banque Centrale des Etats d'Afrique de l'Ouest. It takes into account

[8] The ECOSIT survey shows that Chadian households receive transfers from outside the country. These transfers allow them to almost balance their budget. This category either relates to transfer from family or relatives living abroad or relate to some informal trade activities. According to the United Nations Programme for Development, revenues from informal trade represent almost 2.5% of households' total income; these import goods are principally brought back from the pilgrimage to Mecca.

some flows which are severely under estimated by official statistics, such as the nature and real value of imports. Constructed for 1996, it distinguishes five production sectors and details precisely government income and expenditure. Each flow, exchange or transfer of money, goods and services occurring in 1996 appears in the social accounting matrix.

We consider six sectors: food crop, cash crop, industry, informal sector, commerce and public services. The food crop sector comprises all of the agricultural goods produced by rural households, such as cereals, oilseeds and vegetables in accordance with the Chadian nutrition traditions and uses. This sector also includes the cattle and fishing productions. Chad's livestock is estimated at 5 million animals and constitutes a considerable source of revenue. 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 sector is the most modernized in the country and is a very important source of economic dynamism in the region. Industry includes the production of soap, sugar, cigarettes, oil and various beverages (mostly beer). It also takes into account the production of water and electricity as well as construction. The informal sector corresponds to food processing and small-scale craft production (principally the processing of wood and leather). The commerce sector concerns the trade of domestic goods and imports, and its production is evaluated as the sum of the margin made on transportation of goods between local markets and from foreign to national markets. Public services (by government and related institutions) are not marketed, although they are consumed domestically by households (see Lofgren et al. 2001).

The Labor Market

The total quantity of labor is fixed, but the workers can move across sectors according to a migration function. As in the Harris and Todaro theory of migration (1970), we distinguish between three kinds of wages, the rural wage W_{rur} for workers in food crop sector, the informal wage W_{inf} for the workers in the informal sector and the

modern wage, W_{mod}; for the workers in the modern sector, i.e. industry, commerce and cash crop sectors.[9] In order to be realist, this wage is fixed. The levels of relative wages are endogenously determined. Using ECOSIT data, both the wage bill and the quantity of labor is known for every sector of the economy. Therefore, for the reference year, the formal wage is three times higher than the informal one.

The main assumption of the Harris-Todaro model is that the workers' migration decisions depend on expected income. Hence, a worker will chose to move from the rural to the urban area (i.e. leave the agricultural sector) if the expected income exceeds W_{rur}. We assume that the informal sector absorbs unemployed labor force, i.e, this sector can be considered as an alternative to finding a job in the modern sector. Hence, the expected income for the workers who leave agriculture is:

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

where L_{tot} is the total number of workers in the population, L_{rur} is the number of jobs provided by the rural activities and L_{mod} is the number of workers in the modern sector.

In equilibrium, W_{rur} must equal the expected income outside agriculture. For the producers, the labor demand follows from the maximization program of firms that gives the optimal production level (Figure1).

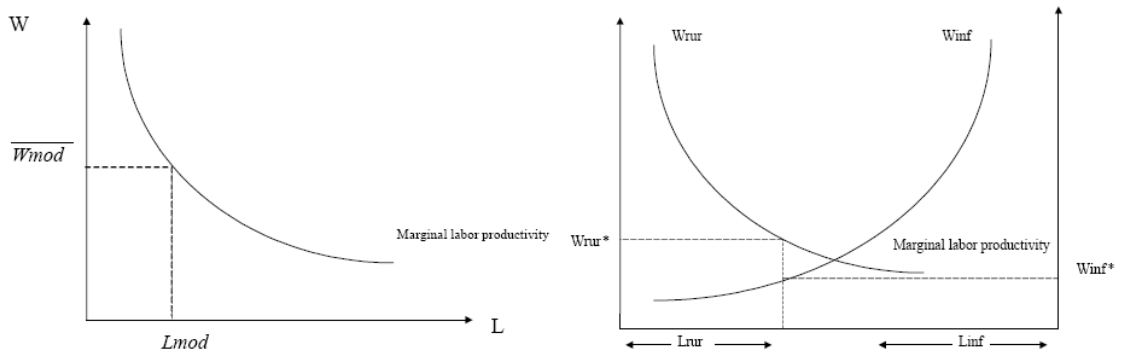

Figure 1. Labor Demand in each Sector

[9] Government and related public institutions also use the same modern wage, although the migration process does not concern this sector which has a fixed labor force.

In equilibrium, the wage equals the marginal productivity of labor and supply equals demand in each market. A full employment situation occurs.[10]

Market Integration

As Chad is a small open economy with highly permeable borders. Informal exchanges could regulate markets and pass on price increases. The country could therefore be a price taker for certain products. In that case, some prices would be exogenous and the equilibrium would be achieved through quantity adjustments (see Ravallion (1986, 1987) and Bhagwati and Srinivasan (1973)). We would like the model to take into account such specificities if they hold and, as much as possible, the degree of segmentation of its markets. In Levy (2004), we therefore carry out a thorough econometric study of regional market integration for the subsistence crop, informal and manufacturing sector. Given the importance of informal exchanges, one cannot use official trade quantities as published by the Chadian authorities in charge of trade registration. Instead, we use prices, in line with the literature (e.g. Ravaillion (1986)). We use the World Tables' long time series for consumer prices (World Bank 1999), which allows such an analysis for three sectors: agriculture, informal and manufacturing.[11] Given our focus on smuggling, we use the informal exchange rate between the Naira (Nigerian currency) and the CFA franc, the two currencies used in the region (data from Ousman Samba-Mamadou (1996) and Azam (1999)). We have been able to lead this study for the major part of the Chadian border exchange area, which includes Cameroon, Nigeria, Central African Republic, and Niger. Unfortunately, we cannot take into account Libya and Sudan, due to lack of data. We find that neither subsistence agriculture nor informal markets are regionally integrated, while a perfect short-run integration with Cameroon and Nigeria is found for Chad's industrial market.

[10] Note that this modeling implies that all the unemployed have an activity in the informal sector.

[11] For more details, see Levy (1999)

These assumptions are included in the model: consumer price for industrial good is exogenous and the equilibrium is reached by quantity adjustment. 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 less than total demand (Q_2), a quantity M_2 of industrial products will be imported so that $DD_2 + M_2 = Q_2$.

III. PUBLIC INVESTMENT RETURN AND ECONOMIC GROWTH

In this section, we use our CGE model to study and compare different investment policies. For realism, only half of the oil revenue is assumed to be employed in these policies. Given the high level of uncertainty about the government behavior, our analysis ignores the use of the other half of the revenue.

For each scenario, the result tables show the changes, induced by the policy, on the main economic indicators. Among them, the consumer price index is a composite price of consumer prices. It is the weighted average of the different product prices, their weights being dependent on their relative share in the consumption basket.

Our modeling of the oil boom is very simple. Chad's government must decide how to use this substantial income. The provision of road infrastructure, the agro climatic differences between the North and the South as well as the agricultural development potential justify the need for public investment in Chad. 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.

Benchmark: Transfers to Households

As a benchmark, we presented a scenario in which the government distributes subsidies to households, i.e. the households receive half the oil revenue. This new revenue represents 6% of their total income. Our assumption regarding savings implies that this new revenue is entirely devoted to consumption.

Table 2. Aggregate Results from Simulation of Subsidies Distribution (in percentage changes from the base value)

Real GDP	Real Hous. Cons	Tot. real wages	Rural real wages	Cons. Price index
0%	5.3%	0%	0%	8
Agric. Prod.	Cotton Prod.	Indus. Prod	Informal Prod.	Comm. Prod.
0%	-22%	-1%	0%	4%

We observe the characteristics of Dutch Disease (Table 2). The domestic price index increases by 8%, as does the real exchange rate (the nominal exchange rate is fixed). The increase in the level of household demand for goods and services induces a substantial rise in the consumer price index. Imports flow into the domestic market to satisfy the new domestic demand. In this case, no growth can occur, and the trade balance deteriorates.[12] Only the commerce sector does not stagnate or contract since it benefits from increased import trade.

Investment in Infrastructure and Roads

In this section, we study the impact of public investment in roads.

Motivation

Chad is the most land locked African country. Moreover, its transport network is severely underdeveloped. Air Tchad, the only company in charge of domestic air transport, has only one aircraft and has recently been experiencing serious financial trouble. Fluvial transport is expensive and unreliable due to the very high variability of the rainfall. There is no railway and there is no plan for building one. The road network is estimated at a mere 263 km, for a 1.5 million km2 territory.[13] For comparison, France is two and a half times smaller but has a 1.5 million km2road network. Even compared to other African road networks, the Chadian case is particularly worrying as 77% of its network is rural tracks, this proportion is 53% in Kenya, 39% in Senegal, 35% in Cameroon and 32% in Tanzania for example (World bank 1997a). Finally, there is no alternative public transport in Chad.

Roads and vehicles are caught in a vicious circle of destruction. The road network deteriorates during each rainy period, causing accidents and damaging the fleet of vehicles, which are old and in poor condition. Conversely, the fleet's condition damages the road network. The cost of transport therefore keeps increasing. The condition of the network is dangerous for travelers too. Without railways or alternative public transport,

[12] It should be noted that, although no growth in GDP occurs, GNP and disposable income do increase once and for all.

[13] Only 30km of roads remained after the civil war. The national network also has 7,000 km of dirt tracks and 24,000 km of rural bush paths.

people travel with commodities, often in similar conditions, i.e. tied up on top of the load. Chadian newspapers frequently report extensive lethal truck crashes (United Nations Programme for Development 1997b). At times during the year, it can take up to five days to drive from the capital N'Djamena to the South while it only takes a day in the dry season. Sometimes, the rain prevents road travel altogether and it can take days for roads to reopen. Each year an average 300 roadblocks are imposed within the country. However, traders often refuse and prefer to bribe their way through. Hence, roads deteriorate further every year.

As a consequence, Chadian transportation costs are among the highest in the world. The share of transport cost on trade margin can reach 85% for some commodities (Table 3).

Table 3. Transport Cost for Cereals from the producing Region to N'Djamena for the Year 1995, in Cfa francs.

Product	Origin	Price	Transport to N'Djamena	Consumer Price	Margin	Transport as % of Margin
Berebere	Am Timan	34	25	87	53	47.2
Millet	Bokoro	62	10	101	39	25.6
Rice	Kelo	155	25	259	104	24
Sorgho	Benoye	54	35	96	42	83.3
Maize	Dibinintchi	77	15	95	18	83.3

***Source**: World Bank 1997a*

We believe that improving road network in Chad would affect not only trade but also human and physical capital by increasing their productivity. This assumption, which has been tested empirically, is strong and therefore needs to be justified. The condition of the road network in Chad induces worse access to health and education services, which are essential elements of the fight against poverty (FAO 1994, World Bank 1974, 1997a). Chad's public services offer 12 regional and 16 local hospitals as well as 373 community health centers almost all located in the four main "sous-prefectures". In theory, these services should benefit 63% of the population, but the lack of roads seriously reduces household access, so that less than 30% of the population actually benefits from these

services. Even when foreign aid and NGO services are accounted for, less than 5 euros per capita are dedicated yearly to health.[14] A similar geographic inequality affects households' access to education. The illiteracy rate reaches 90%, the 1993 population census reports that 70% of men and 95% of women over 15 never went to school, with a very high disparity across regions. Recent studies attest that the last two decades since the official end of the civil war have not allowed for better performance of the system. This inequality particularly disadvantages the poorest and contributes to reproducing inequality and poverty.[15]

Developing road networks is even more important for the centre and the North. Regions with chronic food shortages need to be linked with the South and the Salamat, where crop production is often in structural surplus. Famines occur regularly in the centre and the North of the country, when at the same time surpluses are exported toward Cameroon or Sudan. The lack of roads linking these regions prevents the distribution of products throughout the country. The recent Darfour crisis demonstrates the difficulty of reaching villages landlocked inside the country, as humanitarian aid hardly reached displaced populations and refugee camps in the Sudanese zone of Chad. During the rainy season these areas suffer even more and remain cut off from trade and exchanges. The Salamat region, for example, is often considered to be the granary of Chad but remains out of trade exchanges for a large part of the year while famines occur sometimes only 300km away.[16] Food shortages are exacerbated by the lack of transport infrastructure.

The case of the village of Karal, in the Chari Baguirmi region, illustrates particularly well the stake of road infrastructure development. In the mid 90's, a section of road was constructed, linking Karal to an existing section of road to the capital. The improved access to markets has dramatically increased farmers' income, as well as living standards in the village. Access to new markets in which to sell potatoes, corn and

[14] Qualified doctors and nurses are also highly problematic to find in Chad.

[15] Women are highly discriminated against in the Chadian education system.

[16] In places like Guera for example, famines are endemic and severe in certain years, while excess cereal productions from the South and the Salamat are being exported to Sudan or Cameroon.

vegetables has been a great incentive for production. New products, both equipment and consumption goods, also penetrated Karal's markets. In a short time, farmers have been able to finance a school and a medical centre. Assembled within a cooperative group, hey organized their savings and started the construction of storage warehouses to stock and protect their cereals. Six wells have been installed or restored, substantially improving access to drinking water. Even housing has improved as, slowly, brick buildings replace straw and mud "bouccarous".

Therefore, the embryonic state of the transport network has serious implications for the functioning of markets and household welfare. On the one hand, the extremely high transportation costs isolate regions and hinder the functioning of markets. On the other hand, household welfare is affected by exacerbated food shortages and diminished access to social, health, education and telecommunication services.

Simulation

In the first scenario, one half of oil revenue is invested in the construction and improvement of road infrastructure. The formalization is as follows:

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

where LD_i denotes the labor demand, K_i the capital stock, $A_i.TFPR$ the efficiency parameter and σ_i the substitution elasticity between labor and capital for the sector i.

Moreover, TFPR = $\lambda.(IG*GINV)^{\mu}$, where IG is the initial level of public investment and GINV the growth rate of IG.

The level of development of the road network affects the total factor productivity ($TFPR.A_i$). The productivity of both production factors K_i (private capital) and L_i (labor) is improved by better infrastructures, and therefore better functioning of markets.

The value of λ is chosen in such away that the level of *TFPR* = 1 before the shock (i.e. before any new public investment). With public investment, *TFPR* increases from 1 to $(GINV)^{\mu}$, the level of total factor productivity being: $TFPR.A_i$.

We set $\mu = 0.2$. With respect to the literature, this can be considered as a low value for a country like Chad, with a very low provision of infrastructure.

Existing Empirica Evidence

Our modeling of the impact of public investment in roads infrastructure is based on empirical evidence discussed in Section 3.2.1**.** It is also in line with the existing empirical literature. Recent studies of the impact of this kind of public investment find a substantial increase in the total factor productivity in the whole economy. Ashauer (1989) is among the first to measure the returns of public investments in infrastructure. He shows their impact on the productivity slowdown in the US over 1970-1985. He finds higher returns for public capital in terms of growth, and demonstrates that this kind of public expenditure can improve productivity in the private sector. Empirical works confirm this result for developing countries. For example, Binswanger, Khandker and Rosenzweig (1993) distinguish between different kinds of public investment, among them road building and irrigation systems. They show how investment in infrastructure, such as roads, allows farmers to access markets, reduces the cost of all kinds of transactions and improves total factor productivity. Mitra, Varoudakis and Véganzonès (1998) point out the impact of infrastructure on productivity growth and technical efficiency in the manufacturing sector in India. They show how the lack of infrastructure can limit growth in a developing country. Total factor productivity 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. Herrera and Dessus (1996) deal with the econometric aspect of the previous 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 term growth is underlined and thus explains to what extent investment in infrastructure can improve the total factor productivity of the private sector. The elasticity of public capital with respect to national product is evaluated at 0.2.

Not only does this literature provide a basis for our simulations as it explains how public investment in roads affects the economy (i.e. by improving the total factor

productivity), but it also proposes specific measures of its impact in the case of developing countries. The elasticity of public investment is positive and high in each empirical study. Its value is between 0.2 and 0.7. We take $\mu = 0.2$. With respect to the literature results, and given the very low initial infrastructure provision, this can be considered as a low value for a country like Chad.

Results

The simulation results, which are reported in Table 4, arise due to the following mechanisms.

Table 4. Aggregate Results from Simulation of Infrastructure Improvement (in Percentage changes from base values)

Real GDP	GDP Const. Prices	Real Hous. Cons.	Tot. Real Wages	Rural Real Wages
13.5%	9.5	9%	9%	10%

Agric. Prod.	Cotton Prod.	Indus. Prod.	Informal Prod.	Comm. Prod	Cons. Price Index
18%	64%	27%	12%	28%	1.6

By definition, the change in TFP increases the productivity of every factor, including labor. This increase in labor productivity has the following consequences for wages and demand in every sector. A migration process is the direct result of the change in labor productivity. Since the wage is fixed in the modern sector and labor productivity increases, the demand for this factor rises compared to the initial reference year. The number of workers remaining in the labor market is then lower. Their productivity is higher for two reasons: first because the marginal productivity has been raised by the shock; and second because the number of workers is lower (Figure2).

The quantity of labor employed in the agricultural sector as well as in the informal sector decreases and, at the same time, wages increase. The total wage bill is higher because every worker earns more in this new equilibrium; household income increases by 9%, and so does consumption.

The output of all sectors improves because of the technical progress and because of increases in demand directly resulting from increases in income.

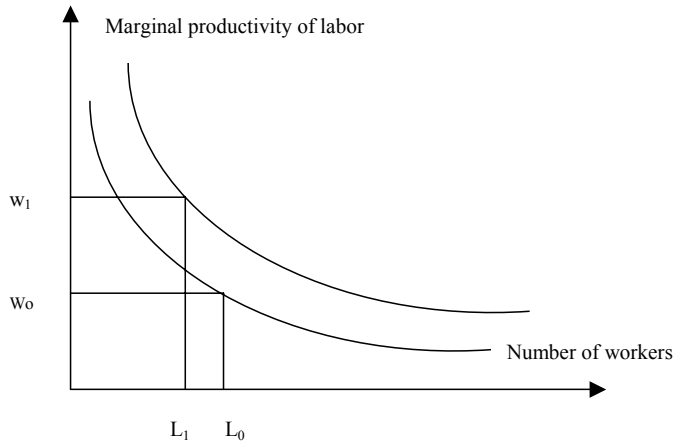

Figure 2. Changes in the Modern Sector Labor Market

The fact that industrial prices are assumed to be exogenous helps greatly to control inflation. The assumption about market integration implies that an increase in demand for industrial products does not necessarily lead to price increases. Therefore, the new equilibrium, in which more goods are exchanged, does not involve an increase in the price of the composite industrial good, which has a fairly high weight in the consumer basket (Figure3).

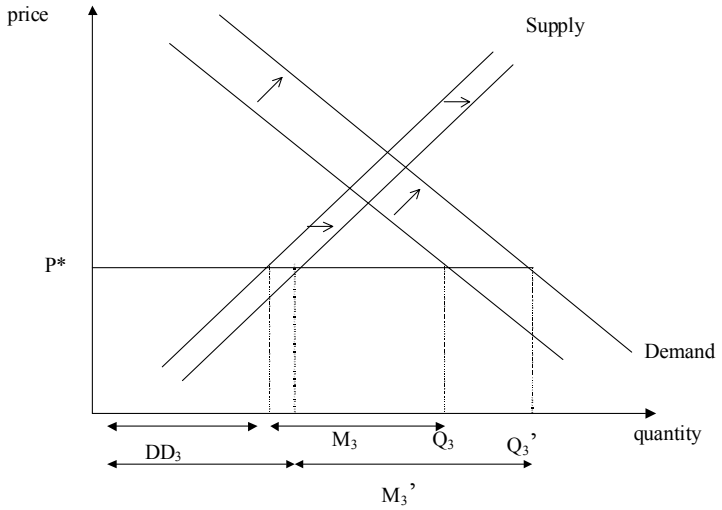

Figure 3. Changes in the Industrial Sector

This kind of policy presents the advantage of preventing Dutch Disease from occurring. Indeed, not only does every sector develop fairly well, but the real exchange rate increases by a mere 1.6%, which means that inflation is at an exceptionally low level given the sudden economic growth. The level of real GDP increases by more than 13%. The food aid dependence is also suppressed as agricultural production increases by 18% (a 10% increase would suffice to fill the average annual food deficit at the aggregate level). Moreover, household welfare must be substantially improved by this kind of infrastructure that, because of its extremely high cost, can only be undertaken by the government. This kind of policy also has the advantage of its returns lasting over time.

Public Investment in Irrigation

In this section, we present a scenario in which public investment is dedicated to the improvement of the irrigation system in the rural sector.

Motivation

The characteristics of the agricultural sector differ greatly across regions. Chad's territory can be divided into three climatic zones.

The North is desert; its size is almost equivalent to that of France, and its population is essentially nomadic, living from trade and livestock breeding. During the transhumance, they lead their cattle through the country. There is scarcely any agricultural production and extremely poor access to water.

In the Centre (Chari Baguirmi, Guera),households often suffer from famine. Rainfall is low but water tables and foodplains (Ouadis) provide an alternative source of water. The capital stock in the agricultural sector is very low.

The South enjoys high rainfall and generates a crop production, often in surplus. The climate, semi-humid and tropical, and the rivers (e.g. the Chari) allow easy access to water. As in the rest of the country, the level of capital stock is also extremely low. The Salamat, the cereal loft of Chad, is the largest producer of cereals. Unfortunately it is

particularly landlocked and distribution of its product is highly problematic on an annual basis.

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 tones of grain (i.e. over 10% of the Chadian production). Therefore distribution problems have generally been the cause of famines and food shortages. But since around 2000, the situation in Chad has started to evolve in a dramatic way. Indeed, the difference between consumption and production growth rates made the problem of food shortage a structural one.

It is therefore urgent that solutions be found to increase Chad's agricultural production. Several FAO and International Food Policy Research Institute reports confirm the urgent need to increase yields in Sub-Saharan Africa. This issue is particularly relevant for Chad. Both in the Sudanese and Sahelian zones, agricultural yields are lower than the Sub-Saharan Africa average according to the FAO statistics (1994). Yields in countries such as Mali, Burkina Faso or Niger are 50% to 100% higher than in Chad.

Chad's resources in renewable water are high considering the population's needs. Indeed, the per capita renewable water resources are twice as high as those of France. Since they are renewable, the use of these resources would not compromise future water availability (FAO 1994).

It is difficult to assess Chad's arable land precisely. AQUASTAT, the FAO department in charge of water related studies, estimates that 1 to 3 million hectares could be irrigated in Chad, while only 14,020 hectares are currently provided with irrigation equipment (FAO-AQUASTAT 1995, 2003). The total use of water for both private consumption and production purposes (agriculture and industry) is less than 35 m3/per capita/year, i.e. less than 1% of the available renewable resources.[17] Agricultural

[17] The Chadian demographic census of 1995 shows that less than 24% of the Chadian population has access to drinking water. This result might even be overestimated as water quality has not been tested. In

production is therefore very dependent on climate and rainfall. A large proportion of water resources are internal, or at least need minimal investment to be employed in the agricultural sector. The use of improved seeds varieties, fertilizer and phytosanitary products are extremely limited, mostly reserved to cotton or cane sugar (these products benefit from more capital intensive production methods). Various production enhancing techniques, such as compost and dung, largely used in neighboring countries to increase yields, are rarely used in Chad. Chadian farmers are often too poor to possess any livestock. ECOSIT reports that only 0.3% of farmers own a traction animal, which is very low even in comparison to other African countries. Moreover, cooperation between stock breeders and farmers is almost non-existent in Chad, unlike in some neighboring countries where arrangements are frequently agreed between farmers and stockbreeders who know how to benefit from each other's activity.[18]

Water management is crucial for agricultural productivity in Chad. Developing irrigation systems and improving access and use of abundant renewable resources in Chad is often pointed out by Chad's development partners as a crucial step toward solving the problem of food shortages and malnutrition.[19] For example, FAO reports that in both Saharan and Sahelian zones, traditional irrigation methods, based on shallow water sheets, allows for irrigation of more than 2000 hectares each.

The very low capital intensity and the asthenic level of investment in agriculture prevent farmers from improving yields in most of Chad. Given that the agricultural sector

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some regions, like Ouaddai and some parts of the oriental Logone and the Tandjile, access to water is particularly erratic.

[18] In Chad, cultural, religious and ethnic conflicts dominate relationships between both groups. Until its recent eradication, the "tsetse fly" endemic disease prevented nomad stockbreeders from the North from accessing green land of the South. Recently the disease has been eradicated, and so no longer prevents the stockbreeders from taking their cattle South during the transhumance period. The recent turn of negotiations concerning oil in the South, as well as the politics of the northern government, has reinforced the divisions between groups, intensified by almost 20 years of civil war. Conflicts for land have become more intense and violent. An increasing number of nomad stockbreeders decide not to return North once they have taken their cattle to the green lands of the South.

[19] Even in the South where the rainfall is good, the malnutrition rates vary among regions from 42% to 76% of the population according to the ECOSIT.

has a substantial potential for development, we quantify the possible impact of a potential public investment policy in favor of this sector.

Simulation

Considering that public and private capital are imperfect substitutes, we define the level of total capital in the agricultural sector as a composite good made of private and public capital:

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

where K_t denotes the total capital stock, K_{pb} the public capital stock, K_{pb} the private capital stock, and A_k the efficiency parameter.

To define the parameters for this CES function, we assume that public capital is half as productive as private capital. Therefore, as for the modeling of production, we use GAMS to determine the parameters and the elasticity.

The agricultural production is then:

$$X_1 = A_1 . \left[\alpha_1 . (Ld_1)^{\frac{\sigma_1 - 1}{\sigma_1}} + (1 - \alpha_1) (KT_1)^{\frac{\sigma_1 - 1}{\sigma_1}} \right]^{\frac{\sigma_1}{\sigma_1 - 1}}$$

where Ld_1 denotes the labor demand for the agricultural sector, KT_i the total capital stock in the same sector, σ_i the substitution elasticity between labor and capital for the sector and A_1 the efficiency parameter of the agricultural CES production function.

Results

Table 5 reports the main simulation results.

Table 5. Aggregate Results from Simulation of Irrigation System Improvement (in Percentage changes from base value)

Real GDP	GDP Const. Prices	Real Hous. Cons.	Tot. Real Wages	Rural Real Wages
14%	8.5	7.5%	17%	27%
Agric. Prod.	**Cotton Prod.**	**Indus. Prod.**	**Informal Prod.**	**Comm. Prod**	**Cons. Price Index**
8%	10%	0%	-4%	4%	7%

The new amount of capital stock in the agricultural sector induces some labor substitution. The quantity of labor decreases, and so does the price of agricultural goods. The quantity produced is higher than in the reference situation. Figures 5 and 6 illustrate the mechanism yielding this result. In this new equilibrium the new quantity produced *Xa** is higher than the initial one (*Xa*), a new lower price *pa** (<*pa*),and a lower labor employed: *La** < *La*. The following explanations justify this result.

The figures below allow the supply curve for domestic farmers to be drawn. Given a real agricultural wage, Wrur, Figure 4 allows us to determine the corresponding new price and quantity. Given the marginal productivity of labor function as well as the production function, we can determine the corresponding equilibrium situation.

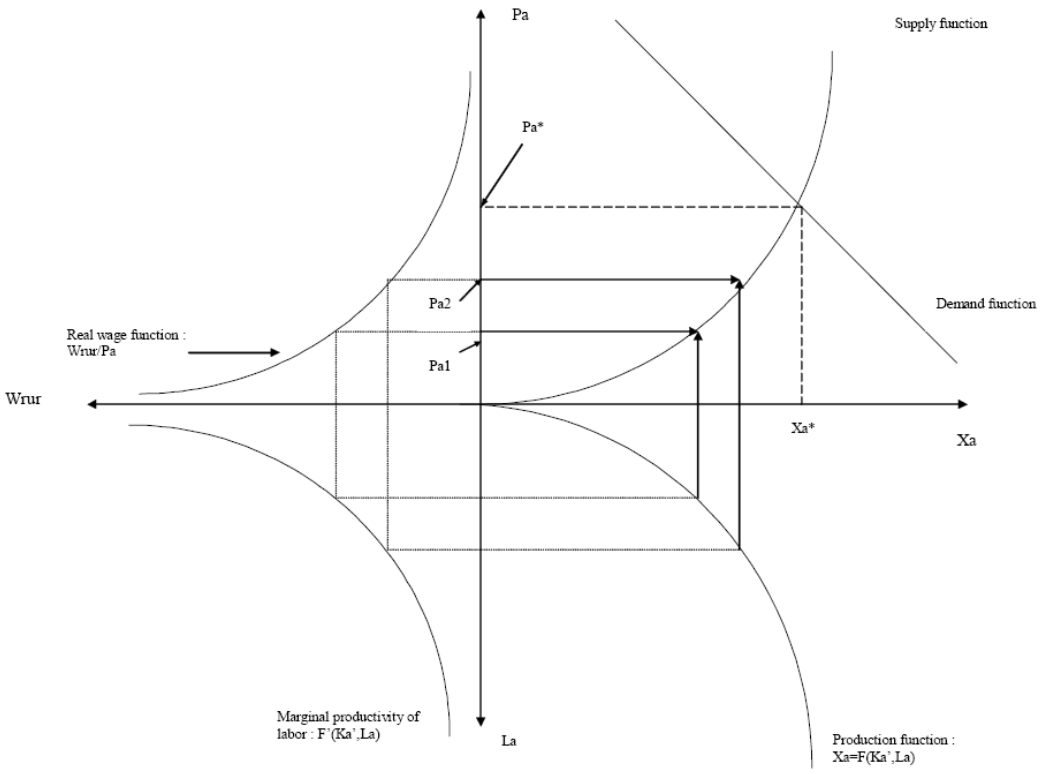

Figure 4. Supply Function in the Agricultural Sector

Now consider an increase in the capital stock. The production function will be modified as described in Figure 5. At the same time, the demand function is shifted

upwards because of the increase in the demand (essentially due to the increase in the household income and the total wage bill being higher, as we will see later on). This figure illustrates that the new equilibrium is characterized by less labor input (La** < La*),more production (*Xa*** > *Xa**) and a lower price (*Pa*** < *Pa**). These mechanisms ignore a part of the CGE model, namely the migration process, which defines simultaneously nominal wages. Given that the labor market is not taken into account, these figures are a simplified version of the mechanisms resulting from the simulation. They illustrate a partial equilibrium for the agricultural sector. Nonetheless, this simplification is useful to understand the impact of the shock to this economy.

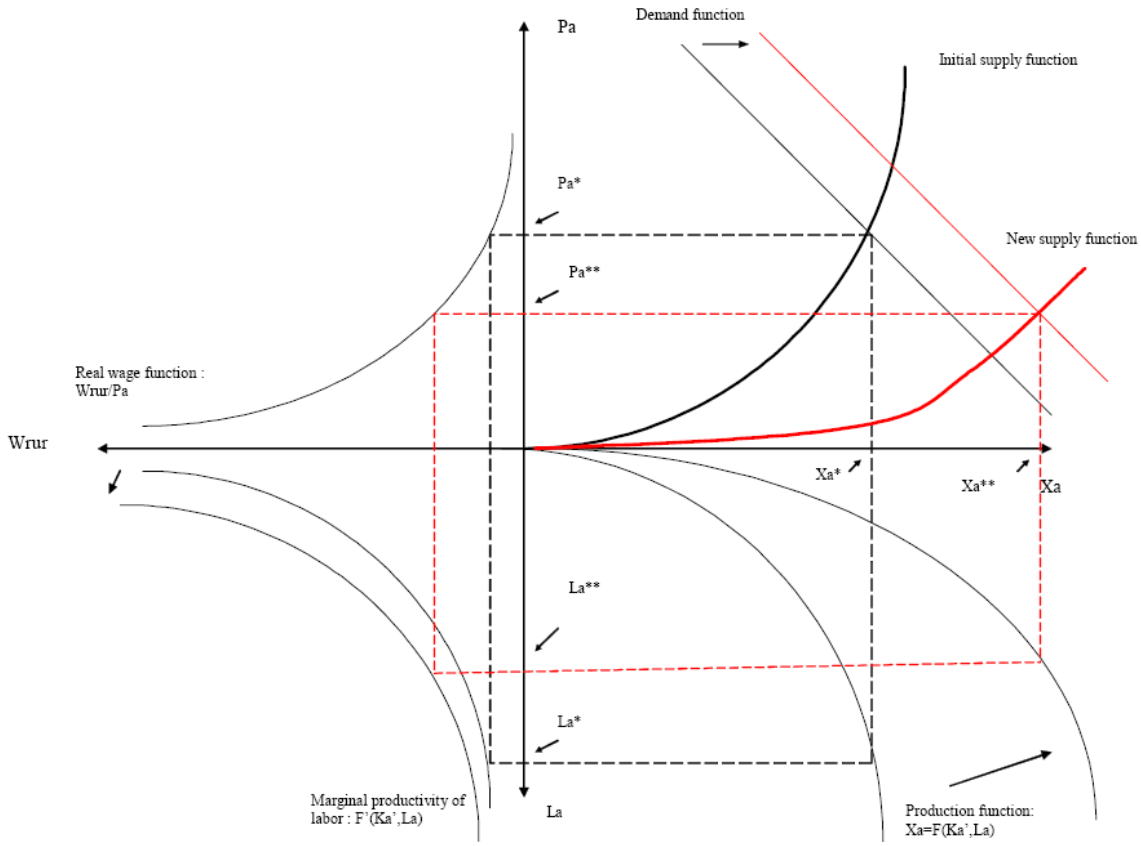

Figure 5. Changes in the Supply Function of the Agricultural Sector

The cash crop sector benefits from the decrease in the agricultural price because its main intermediate inputs are coming from the food crop sector, the price of which decreases. While the unitary labor cost remains unchanged (the modern wage, Wmod, is

fixed), the cost of intermediate consumption decreases. The profit per unit rises significantly for this sector, and so does its output, all of which is exported. Consequently, the commerce sector grows because of the new quantity of goods for sale in national and foreign markets. Workers migrate to the modern sector (and more specifically to cash crop and commerce sectors). The flow of migrants is predominantly 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 agricultural and the informal sectors entails an increase in wages, whereas the labor demand rises in the modern sector; the total wage bill grows by 17%. The real income of rural households improves (27%), and the total household consumption increases by 7.5%.

Nevertheless, this policy induces a rise in productivity of one traded sector vis-a-vis the others and an increase in the overall price index. These effects are similar to some of the effects of Dutch Disease and deserve some comments. Although it proposes different views on which sector should decline, the Dutch Disease literature predicts the contraction of part of the economy as well as a decline in growth and a worsening in poverty and inequality. The only similarity that our case has with Dutch Disease is the increase in the price index, which means an increase in the real exchange rate. But the impact on foreign trade is very limited and the development of the tradable is not affected in our case. The informal sector is the only sector to contract, and its contraction is explained by the migration of workers to the modern sectors. In addition, there is an increase in GDP as well as a major improvement in the income of the poorest part of the population.

Therefore, the main effects of this policy are as follows. First, rural households benefit most: their income improves by 27%. Second, the capital stock of the agricultural sector increases, leading to a productivity improvement in the longer term. Agricultural sector growth will also continue in the following periods. This might be particularly important as Chad is highly dependent on food aid. Third, the national product growth is slightly higher in this scenario than in the previous one (which corresponds to the

traditional development policies suggested by Chad's development partners). In fact, the lower level of imports improves the trade balance and economic growth (which is twice that of the reference period).

These results suggest that policy makers should take the agricultural development potential into account; a sit could yield development, growth and poverty reduction.

Investment Complementarity

The comparison of different kinds of public spending confirms the relevance of public investment. The results of the simulations concerning road infrastructure and irrigation allow us to evaluate their respective impacts on various economic indicators. We are now able to compare these two polar cases of public investment policies, and to understand their particular advantages in terms of growth, rural development and household welfare improvement. However, the complementarity of these measures has not been 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 dedicated entirely to one kind of infrastructure.

Denote by α the share of public investment devoted to irrigation and $(1 - \alpha)$ that dedicated to roads. The two scenarios considered so far correspond to $\alpha = 0$ (and $\alpha = 1$ respectively. We now consider any α between 0 and 1. In other terms, we can draw the curve linking the two particular levels of economic indicators obtained before (see Figure 6). Given our macro-closure rule, it is not possible to make welfare comparison per se. In fact, we can not compare household consumption without looking at trade balance, which is different in the two scenarios. For that reason, we draw both curves together on the same graph (Figure 6).[20]

Considering real GDP, the optimal policy corresponds to $\alpha = 0{:}5$. Real GDP increases with while the share of public investment dedicated to irrigation stays below 0.5 and decreases thereafter.

[20] It is possible though to make GDP comparisons.

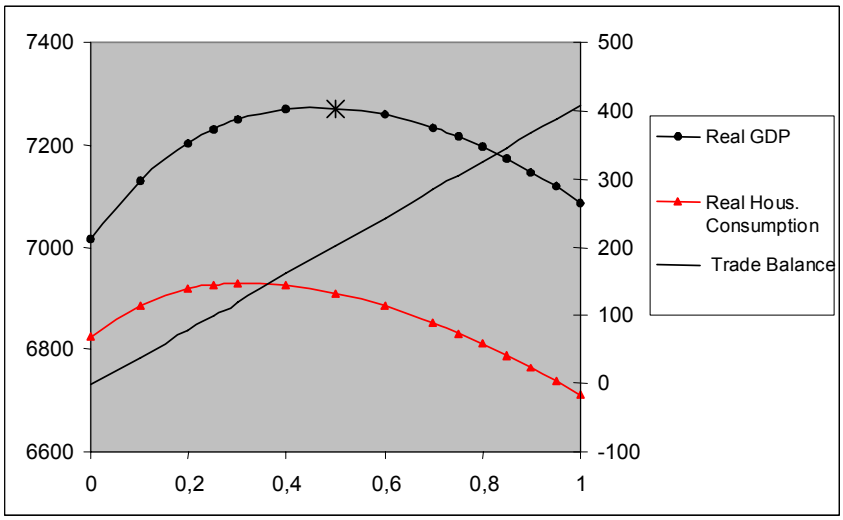

Figure 6. Change in Real GNP and its Components According to the Value of α (note: the right-hand scale is for trade balance)

The change in the level of real GDP is due to the changes in foreign trade and in final consumption. Concerning foreign trade, the level of industrial imports increases with the share of investment devoted to infrastructure (Table 6 and Figure7).

Table 6. Aggregate Results on Trade from Simulations (in percentage changes from base values)

	Agr Export	Cotton Export	Ind. Export	Informal Export
α= 0	30%	64%	27%	12%
α = 0	11%	10%	0%	-22%

	Agr Export	Cotton Export	Balance of Trade (Million cfa)
α = 0	10%	42%	0
α = 0	3%	5%	408

This can be explained by the demand for industrial imports, which grows with the level of intermediate consumption. Indeed, the growth of the modern sectors (which is inversely related to α) requires the import of many kinds of goods, which are not produced in Chad. Developing the modern sectors induces a higher dependence on foreign trade (both on imports and exports), where as the development of the agricultural sector is more autonomous.

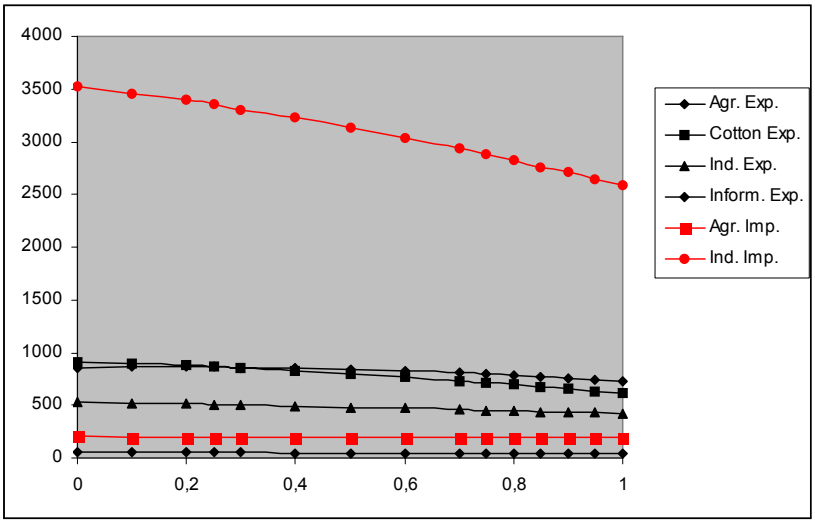

Figure 7. Change in Trade's Components according to the Share of Public Investment Dedicated to Irrigation

Interestingly, the different public investment policies have different impacts on final consumption. Since government consumption is exogenous (and so independent of α), the evolution of final consumption is due to households' consumption, which equals their income. In order to examine α's effect on final consumption, its effect on the components of household income is detailed (Figure 8).

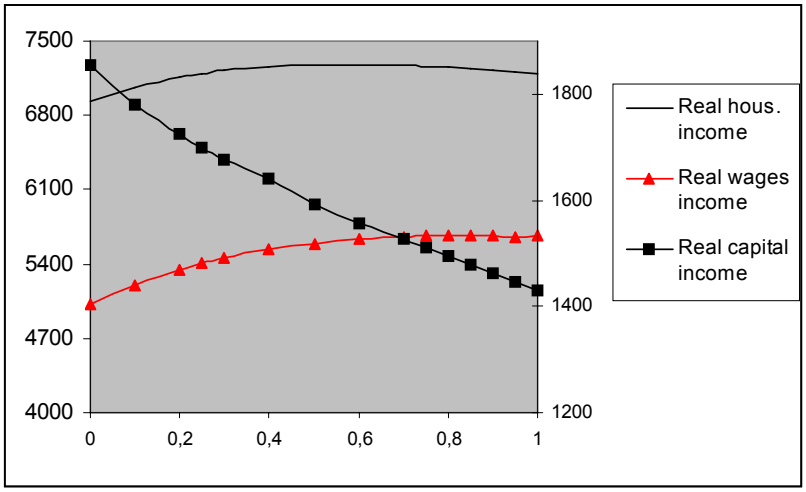

Figure 8. Change in Household Income and its Component according to the Share of Public Investment Dedicated to Irrigation (unit : million Cfa francs) (Note: The right-hand scale is for real capital income)

Although household consumption reaches a higher level in "road" scenario (scenario 1) than in "irrigation" scenario (scenario 2), its variation across these sets of simulations is small. The level of household income is maximum for α =0.3. However, the share of capital and labor income varies considerably according to the kind of policy undertaken. The share of capital income decreases with; while the share of labor income varies in exactly the opposite way. Since the profit sharing rate is exogenous, the share of public investment devoted to irrigation reduces the total level of profit. The increase in prices (positively correlated with α) raises the cost of intermediate consumptions. Moreover the total sum of wages reduces the profits of firms.

The distribution of households' income differs substantially depending on 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, households' income and consumption are highest for policies which include irrigation improvement (i.e. $\alpha > 0$).

Figure 9 summarizes the evolution of the main economic indicators according to the simulated policy. These results confirm that using the future oil revenue to improve water access in Chad's rural areas allows for poverty reduction, and, at the same time, generates substantial economic growth.

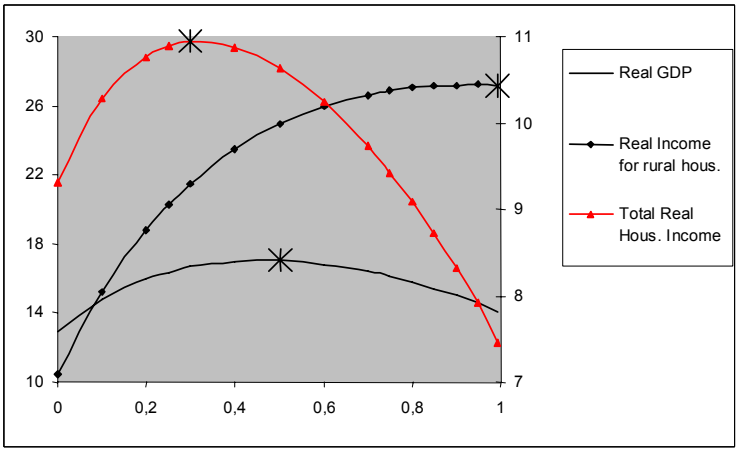

Figure 9. Evolution of the Main Economic Indicators according to the Value of α (the maximum for each is indicated with a black cross) (Note : the right-hand scale is for rural households real income)

Robustness

The elasticities used in the model are exogenous. They are inspired from various CGE models developed for other Sub-Saharan countries, such as the standard IFPRI CGE model (2001) which has been used for Zambia, Tanzania, Ethiopia and Malawi, among others. Therefore, it is important to test the robustness of our results, i.e. determine their sensitivity to the elasticities' values. These elasticities concern substitution between capital and labor in the production function, as well as substitution between domestic and foreign products, namely imports in the Armington function and export in the CET function. In this section, we change the value of each them, one by one and control for the change in the simulation outcome. Only variation rates over one percent from the initial results are reported in Tables A and B (Appendix).

The results are fairly robust to changes in all elasticities, except for the elasticity of substitution between capital and labor in agricultural production in scenario 1, and in cotton production in scenario 2. In fact, most of the changes have a minor impact, generally below 2% change from the initial simulation results. However, in scenario 1, the value of the level of substitution between labor and capital in the cash crop sector may affect the outcome of the simulation in a very intuitive way. When the elasticity of substitution between labor and capital increases (its original value being 0.6), the demand for labor increases. We have seen in the Section 3.3 that the cash crop sector benefits the most from the investment policy in transport. However, the fact that the stock of capital cannot be modified in our model, explains that the development of the cash crop sector is more constrained when labor and capital are weaker substitutes for each other. This sector benefits more from the measure when labor more easily replaces capital. This result is particularly realistic as the Chadian cash crop sector, mainly located in the very south of the country, suffers greatly from the lack of roads. CotonTchad (the public firm responsible for buying cotton from the farmers) even financed the construction of some road networks in the 90's.

For scenario 2, the tests reveal the sensitivity of the results to the parameter of the production function in the agricultural sector. Indeed, given that the simulation consists

of increasing the capital stock, it seems logical that the higher the substitution between both factors, the easier it is to increase the production and the greater the impact of the measure. We can also conclude that only very low values of the agricultural production function elasticity σ_{x1} (under 0.3, while the initial value is 0.6) diminish the impact on economic growth. However, this assumption seems implausible in the case of Chad, where the level of capital stock in the food crop sector is extremely low and the investment largely insufficient. One can therefore expect substantial impact from such an investment policy. It should be extremely easy to replace workers in the agricultural sector with new capital, such as irrigation systems or cattle.

Finally, note that the values chosen for each simulation to embody the impact of the shock hardly affect the results of the study.

IV. COMMENTS

This paper illustrates that the three most common symptoms of Dutch Disease (decline of some specific sectors, increase in the real exchange rate, worsening of poverty and inequality) may not appear when the agricultural sector receives enough support. All our simulations generate a substantial increase in real GNP, without causing the decline of any sector. Sachs and Warner (1997) who studied 95 developing countries between 1970 and 1990, demonstrated the negative impact of external trade shock on their growth. Only Malaysia and Mauritius were able to sustain a 2% annual growth rate between 1970 and 1980. The results obtained for Chad are particularly positive with regards to this issue. The loss in competitiveness which generally affects sectors most open to international trade and therefore to foreign competition, has also been avoided in the scenario studied here. In the same way Indonesia developed a strong agricultural policy to support its rural sector, and by doing so succeeded to limit the increase in its real exchange rate (Pinto (1987), Gelb (1986)). The present work attests the efficiency of some public investment policies in the case of Chad.

One of the most interesting results concerns poverty. Many NGO reports on resource booms (e.g. Ross (2001) for Oxfam), strongly denounce the link between the exploitation of natural resources in developing countries and the worsening of living standards. Ross (2001) studies 50 natural resource exporting countries, mainly developing ones, and concludes that their poverty worsens much more than in countries not engaged in this type of trade. Poverty indicators appear to be highly correlated with mineral or oil dependency. Not only do natural resource windfalls fail to reduce poverty, but they are often associated with higher infant mortality rates, lower life expectancy, and worse levels of health and education. Confirming Auty (1994), Fields (1989) or Sarraf and Jiwanji (2001) results, Ross insists on the fact that inequality similarly increased in booming periods for the large majority of developing countries. Countries which succeeded to perform well in economic terms, like Botswana, Indonesia or Malaysia, were those that adopted policies targeting the poor. Our simulations for Chad are very satisfying for both poverty and inequality.

Aside from Dutch Disease, this paper broaches different topics relevant to economic development in Africa.

The case of Chad illustrates well the work on hunger by Sen (1990) and Dreze and Sen (1989), as they explain that famines are, in most developing countries a problem of distribution of goods. Famines, which have occurred in the last century, did not necessarily occur due to unavailability of food but rather due to difficulties in access to it. Drought hits poorest farmers first. Household access to food suffers from poor distribution networks, either due to market forces or to bureaucracy. Ravallion (1987) explains that markets that are not integrated enough are unable to prevent famines. Developing transport infrastructure answers this market failure.

This paper also confirms the relevance and the considerable stakes involved in agricultural policy in Sub-SaharanAfrica. Institutions such as IFPRI (Delgado et al. (1987), Delgado (1995), Rosegrant and Perez (1995), Rosegrant (1997)) or the FAO (Kijne (2001)), recommend supporting the development of agricultural sectors in many Sub- Saharan countries. They argue that the most tangible method to fight poverty in Africa would be through increasing yields and agricultural productivity, as at low levels they induce low wages and asthenic demand. For Kijne (2001) "in counties with large poor rural population, agriculture is the only source of the increase in rural farm and non-farm incomes needed to enable the rural poor to afford more and better food". According to the World Bank (1997), "for Africa, prosperous agriculture is the engine without which poverty cannot be managed in a sustainable way and food security cannot be assured". The role of agriculture is all the more crucial as agricultural products contribute on average to 35% of the continent's total, 40% of its exports, and employs 70% of its population. 70% of the poor in Africa live in rural areas and depend on agriculture to survive. Considering the very high potential of land use and the advancing desert, increasing productivity by efficiently managing available resources such as water and land, is, more than ever, essential for these countries. Kijne (2001) argues that: "Irrigation is key to the national strategy for increased food production in many Sub-Saharan African countries. The potential for more irrigation depends not only on the physical

characteristics of available soil and water resources, but also at least as much on political choices, investment capacity and likely returns on investment.

Our focus is on the economics of oil or mineral booms. However, political and institutional determinants are also of considerable importance. After initially denouncing the inference of risk for the development of either one or another part of the economy, the literature started pointing out the political risk inherent to natural resource booms, and the link between such booms and conflicts in developing countries (Collier and Hoeffer (2000), Ross (2001), Stevens (2003)). A vicious circle might indeed occur when rivalries arise to benefit from the windfall. Corrupt institutions, infringing on democracy in order to stay in power, overspending on military expenditures to repress democratic bursts or ethnical claims, lead from one to another, especially in countries where resources are located in different regions from those that the government is originally from. Resource exploitation often implies environmental damage and affects the local populations. Land expropriation and human rights violations are often observed, inciting claims and rebellions. The most exacerbated tensions risk degenerating into civil war. According to the World Development Report 2001, nothing is more devastating than civil war, "destroying physical, social and human capital, reducing investment, diverting public spending from productive activities and driving highly skilled workers to emigrate." The poorest part of the population is usually affected first (Azam (2003), Azam and Hoeffler (2003)). Collier and Hoeffler (2000) assess that the risk of civil war in the first five years of a natural resource boom is 23%, compared to 0.5% in similar countries not experiencing such a boom. Stevens (2003) discusses the different political factors which might influence the occurrence of conflict; such as democracy, governance, macroeconomic policies, or elite proximity to power. Over the last thirty years, the risk of conflicts has been strongly associated with the probability of increasing military spending.

VI. CONCLUSION

Using the case of Chad, this study illustrates that Dutch Disease is not an unavoidable consequence of natural resource booms in developing countries.

Chad is a very poor, small open economy, which began exploiting its oil reserves in 2004. We represent it with a CGE model which follows the structuralist tradition. However, we adopt an original approach to analyzing the agricultural sector, with an in-depth modeling of migration, trade, market integration and price formation. We consider two kinds of public investment as different uses of oil revenue; irrigation and road infrastructure, and show how they can affect the economy positively.

The results show that each one of these investment policies presents particular advantages in terms of growth and household welfare. Further, we assess the impact of different policies on the poorest population parts. Remarkably enough, water management policies generate results similar to more traditional policies aiming at the development of transport infrastructure in terms of economic growth and household income. Moreover, improving access to water in the rural sector presents the advantage of targeting rural households, whose income is consequently found to increase by 27% in one year. We also simulate a range of policies mixing the two types of investment. The study provides enough elements to discuss the kind of policy that should be adopted according to the importance given to rural household welfare. Analyzing the complementarity of these two kinds of investment could indeed suggest what part of the oil revenue should be dedicated to the agricultural sector-provided that the objective function of the Chadian government is known. As well as the positive impact on growth and household income, these policies have other advantages.

First, these policies improve productivity and/or capital stock and therefore will continue to affect the economy over the years following the shock. The revenue considered here is equivalent to the average oil revenue for one year, but the new investments increase the capital stock and the technical progress for several years.

Moreover, if public investment is repeated during the oil boom period, the effects will increase and a sustainable growth process could be engaged.

Second, our study analyzes investment in the agricultural sector as publicly funded by oil revenue. However its conclusion can remain unchanged if investments are financed by foreign aid or international institutions. The modeling of the oil boom is such that the conclusions of this paper are not limited to Chad, or even to countries experiencing resource booms but canal so be applied to developing economies suffering from a similar agricultural pattern and benefiting from particular financial windfalls.

These results illustrate the stakes involved in supporting the food production in Sub-Saharan Africa and confirm that even in the case of a very poor open economy, with well integrated regional trade, agriculture could generate income and reduce inequality.

However, if the economic risk is analyzed in this paper, the political risk is not. And one possible way to look at our results is to consider them as an illustration that resource booms can be a blessing for developing countries. Such booms create a risk which is certainly more political than economic. The risk for Chad is to see oil revenue wasted, and claims and civil conflicts arising.

The tripartite agreements between Chad's government, the World Bank and the oil consortium, might offer an opportunity for transparency and good management of the oil revenue. As countries such as Angola, Azerbadjan, Kazakhstan, Papua New Guinea are about to receive massive in flow of revenue from their mineral, oil or gas reserves, this paper provides thoughts about the stakes involved in good management of the windfall. It suggests that a proper use of the revenue, in particular through policies supporting vulnerable parts of the economy, may prevent the occurrence of Dutch Disease. If revenue can create a serious opportunity for development and poverty reduction, it certainly is a good opportunity for corruption as well, feeding political claims and increasing the risk of conflict.

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VI. APPENDIX

Sensitivity Tests for the Scenario 1 (differences in variation rates*)

	Scen.1	ρ_i=0.3	ρ_i=0.9	φ_i=0.3	φ_i=0.9	σx_1=0.2	σx_1=0.6	σx_2=0.2	σx_2=0.6	σx_3=0.2	σx_3=0.6	σx_4=0.2	σx_4=0.6	σx_5=0.2	σx_5=0.
Production															
agr.	*22*								-1						
coton	*64*							-15	**30**						
manuf.	*27*										**2**				
informal	*12*								-3						
trade	*28*								**2**						
Imports															
agr.	*10*	5	**-5**					**-2**	3						
manuf.	*43*							**-3**	5						
Exports															
agr.	*30*			-5	+2			**2**	-3		-1				
coton	*64*							-15	**30**						
manuf.	*27*										**3**				
informal	*13*					-1		**4**	-9		-3				
Cur. Bal. Sold	*0*							**0**	0		0				
Hous. Cons.	*9*														
Rural real hous. income	*11*								**5**		**1**				
Tot. real wages	*9*								**1**						
real GNP	*13*														
Price index	*0*								**-4**		1				

**Each cell indicates the difference between the variation rate of the variable in the scenario 1 and in the test, except for the current balance sold which is in value. This difference is indicated only if its value is above 1%. When the tests entails a better outcome than the scenario 1, the figure is in red heavy type.*

ρ_i is the parameter of the Armington function (import function) for the sector i, its value (0.6 in the initial model) is changed for each sector simultaneously.
φ_i is the parameter of the CET function (export function) for the sector i, its value (0.7 in the initial model) is changed for each sector.
σx_j is the parameter of the production function for the sector j (initially equals to 0.6), it gives the elasticity of substitution between capital and labor.

Sensitivity Tests for the Scenario 2 (differences in variation rates*)

	Scen.2	ρ_i=0.3	ρ_i=0.9	φ_i=0.3	φ_i=0.9	sk=5	sk=7	σx_1=0.3	σx_1=0.9	σx_2=0.2	σx_2=0.6	σx_3=0.2	σx_3=0.6	σx_4=0.2	σx_4=0.6	σx_5=0.2	σx_5=0.6
Production																	
agr.	*8*																
coton	*10*									-3	**5**						
manuf.	*0*																
informal	*-4*							-2	**4**								
trade	*4*																
Imports																	
agr.	*3*							2	**-3**								
manuf.	*5*							-1									
Exports																	
agr.	*11*							-3	**4**		-2						
coton	*10*									-3	**5**						
manuf.	*0*																
informal	*-22*			**7**	-5			-8	**10**								
Cur. Bal. Sold	*408*							401	**417**								
Hous. Cons.	*7.5*							**6**	-2								
Rural real wages	*27*							**10**	-7								
Tot. real wages	*17*						-2	**4**	-14								
real GNP	*14*							**2**	-2								
Price index	*7*							4	**-5**								

**Each cell indicates the difference between the variation rate of the variable in the scenario 2 and in the test, except for the current balance sold, which.is in value. This difference is indicated only if its value is above 1%. When the tests entails a better outcome than the scenario 2, the figure is in red heavy type.*

ρ_i is the parameter of the Armington function (import function) for the sector i, its value (0.6 in the initial model) is changed for each sector simultaneously.
φ_i is the parameter of the CET function (export function) for the sector i, its value (0.7 in the initial model) is changed for each sector.
sk is the parameter of the agricultural sector capital function (its initial value is 0.6) .
σx_j is the parameter of the production function for the sector j (initially equals to 0.6) , it gives the elasticity of substitution between capital and labor.

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