The impact of Developed Countries' Cotton Subsidies on the Malian Economy: a CGE Assessment

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Abstract

The impact of the United States and European Union subsidies on world cotton price has been an important subject in recent years. This paper examines the impact that would have the removal of these subsidies on Malian economy (GDP, public accounts, and households' income). The issue is adressed with a computable general equilibrium model detailing malian cotton sector. Results show a positive impact on GDP as well as on households and government income. These results are robust to systematic sensitivity analysis taking into account parameter uncertainty.

Keywords: cotton, subsidies, Mali, general equilibrium.

JEL Codes: C68, 013, Q17.

1 Introduction

The impact of the United States and European Union's cotton subsidies on world cotton market has been subject of numerous debates in recent years (World Bank, 2002;Ingco and Nash, 2004; Bouët et al. 2004 etc.). The WTO sessions have stressed on this subject recently (Doha Round) and during these debates, cotton appears as a particular commodity. In fact many developing countries heavily depend on cotton for their exports. Countries like Mali and Burkina Faso have about half of their export earnings coming from the cotton sector.

Since the complaint of Brazil against the United States in 2003, many studies attempted to assess the impact of developed countries subsidies (essentially the United States and the European Union) on world cotton market (Araujo Bonjean et al. 2006, Poonyth et *al.* 2004, Goreux, 2003 etc.), with contradictory results. However, this impact seems to be quite limited on world cotton price: 3 to 17%. Some of these studies go beyond the impact on world cotton price and try to estimate the effects (potential gains) on national economies. The study by Goreux (2003) estimates that developed countries subsidies damage West and Central African cotton producing countries exports by 250 million US dollars. Another study carried out by the International Cotton Advisory Committee (ICAC, 2002) states that the loss of exports earnings for Mali is 43 million US dollars. Despite the profuse literature on world markets, few studies try to assess the impact of the subsidies on national economies and beyond the potential gains in exports earnings. One can however mention the paper by Minot and Daniels (2002) for Benin and Boccanfuso and Savard (2007) for Mali. Minot and Daniels (2002) ran a one sector microsimulation model for Benin and assess the impact of cotton price variations on households' welfare. It is straigtforward to see that this strategy ignores general equilibrium effects as well as second order ones. Boccanfuso and Savard (2007) built a micro-macro model to study the impact of cotton price variations and import prices of some cereals on households welfare. However, the model is very standard in its structure and does not represent the Malian economy, particularly the cotton sector.

We try in this paper to seriously reconsider the question of the impact that the removal of the subsidies would have on the Malian economy and particularly on households. To this end, we start with a standard general equilibrium model (Dervis, Robinson and De Melo, 1982; Lofgren et al., 2002). The standard model is then modified essentially in the agricultural sector and the labor market. It is worth noting that cotton production in Mali is observed in households who also produce cereals. These cereals are substitute or complements to production for seed cotton (Nubukpo and Keita, 2005; Hugon, 2005). The choice of crops to be grown and factors are made as part of a single income or subsistence strategy. Furthermore, the cotton sector is managed by a public monopoly with a minimum guaranteed price for producers. These two aspects are very often neglected in the literature of general equilibrium modeling in agriculture. We take into account these aspects by modeling the relationship between the public monopoly and cotton growers as mentioned above. Following Quizon and Binswanger (1986) and De Janvry and Sadoulet (2002), millet, maize and cotton sectors are treated in a multimarket framework. Instead of standard production functions, we will work with supply functions that are derived from a generalized Leontieff profit function including the three crops mentioned above. We also take into account home consumption since a large part of food production in Mali is not sold on markets. For example, home consumption represents about 70% of total millet and maize production. Finally migration issues are introduced in an extended Harris-Todaro framework to take into account rural-urban migration flows observed in Mali.

The remaining of this paper is organized as follow: the next section present an overview of the Malian cotton sector and the third one the social accounting matrix used for calibration. The fourth section introduces the model while the fifth one displays the results. The sixth section is a robust analysis and the last one concludes.

2 Overview of the Malian cotton sector

Mali is among the first cotton growers in Africa (after Egypt and Burkina Faso) with an estimated production of 600,000 metric tons. This production is made by 160,000 farms distributed in the south of the country and covering about 1,000,000 acres.

Typical farms are small scale family farms (5 acres on average), enrolled in producers' organizations. Producers organizations are directly involved in the management of the sector, by participating in the price determination mechanism. They also have to make sure that cotton seed is commercialized and lastly they provide inputs to their members.

Although the number of producing farms seems to be limited, about 2 millions of people depend directly or indirectly on the cotton sector in Mali (Nubukpo and Keita, 2005). From a macroeconomic point of view, cotton accounts for 20% of agricultural production, 7% of GDP and represented until recent years half of the export earnings (180 billion F CFA). This significant position is now attenuated due to the recent years gold boom. However cotton still represents 40% of Malian exports. In terms of public finances, the cotton sector contributes to 10 billion FCFA.

Cotton was initially grown in Mali for domestic use. It becomes an industrial crop with the French colonization and particularly after World War I when the french cotton national company (CFDT[1]) was created. When Mali became independent in 1960 and until 1974, the sector was managed by the CFDT, a public monopoly. In 1975, the CFDT was replaced by CMDT, a semi-public company owned by the Malian government (60%) and by CFDT[2] (40%). This new company was first in charge of collecting and transforming cotton seed into fiber. Cotton exports were under the responsibility of another public company (SOMIEX)[3]. While exports were made by SOMIEX, the OSRP (another public company), was in charge of stabilizing and regulating prices and of receiving related payments. The OSRP office remunerated CMDT and SOMIEX on a fixed basis. Due to large cumulated deficits that occurred with the fall of world prices, the cotton sector was restructured in the early eighties. In 1986 SOMIEX lost the monopoly and CMDT became an entirely autonomous entity. Nowadays, the sector is still organized through contracts between CMDT and the government. CMDT manages the cotton production by providing inputs to producers and exports the fiber on world markets.

[1] Compagnie française de développement des textiles

[2] now Geocoton.

[3] Société malienne d'importation et d'exportation

Besides organizing the production, CMDT is involved in some "development activities" (construction of rural roads, producers training etc.). To many observers, particularly advocates of privatization, these additional activities largely contribute to CMDT's deficits.

2.1 Price establishing mechanism

Before the 2005 agreement between CMDT, producers and the government, cotton price was established after a direct negotiation amongst CMDT and cotton growers. The system consisted of a floor price with a prime if world prices were to increase. The exact mechanism behind this procedure was relatively opaque. Furthermore, the government had to fulfill the successive deficits.

In 2001 world cotton prices fell down to an historical level. The value of Cotlook A index was 40 US cents/lb., the lowest level since 1973. Many cotton sectors in Africa suffered from this price decline. In Mali, CMDT reacted by drastically reducing producers price. Producers organizations reacted by a boycott and the production fell by 50%. To come up with the crisis, the government set up large consultations which led to a new price design mechanism involving CMDT, the Government and cotton producers unions in 2005. This new mechanism fixes seed cotton price as follows:

- At the beginning of the campaign, a guaranteed minimum price is announced to producers. This floor price takes into account costs of production of both CMDT and the producers.
- At the end of the campaign, a potential bonus could be paid to producers if world prices have increased and if the gross benefit of the sector is positive. This gross revenue is calculated taking into account the evolution of the world price between March of campaign n and April of campaign n+1. In case the gross revenue of the sector is positive, 58,7% of the revenue goes to the producers and the remaining 41,30% to CMDT. In reality, only 49,6% of the revenue goes directly to producers and the remaining 8,7% abounds a stabilization

fund directly managed by producers and aiming at guaranteeing the minimum price. In fact, the Stabilization fund pays to producers the difference between the effective -theoretical- price of the campaign and the minimum guaranteed price. If the sector exhibits a deficit, the CMDT is obliged to pay to producers the minimum price. At a second stage it will be refunded by the stabilization fund. The setting out of this mechanism is supervised by a special committee composed of :

- a representative of the ministry of Agriculture
- a representative of the ministry of trade and industry
- a representative of each producers unions
- the Chief executive officer of CMDT
- a representative of DAGRIS (Geocoton)
- the Director of the "Office de la haute vallée du Niger", OHVN.

With this new mechanism, cotton producers have received 2.1 billion FCFA of bonus in the 2005/2006 campaign. Also, since the beginning of the system, the minimum price has not been revised downwards.

2.2 Future of the sector

Since 2001, notably due to the persistent deficits of CMDT (50 billion F CFA in 2004 and 172 billion of cumulated deficits since 1999) and under the pressure of the World Bank, the Malian government has decided to privatize CMDT and to liberalize the cotton sector. This reform will consist of separating the areas of production into three or four regions. The beneficiaries will be in a monopoly situation in each sector. Due to producers' hostility and political issues, the reform has been postponed many times. However in August, 2008, the Malian assembly has voted the privatization bill and the invitations to tender will be launched soon.

3 The Malian Social accounting matrix

The general equilibrium model developed in this paper uses a 2001 disaggregated social accounting matrix for Mali built by the World Bank (Nouve et al. 2001)[4]. Initially composed of 17 sectors of production and 21 commodities, we have made an aggregation into 10 sectors and commodities with five agricultural commodities which are of particular interest to us. This aggregation led to the following sectors: maize, millet, seed cotton, other agricultural products, mining commodities, cotton fiber, other industrial products, marketable services and non marketable services. The thirteen production factors in the initial SAM were aggregated into 3: skilled labor, unskilled labor and a composite factor including capital, land and formal business owners. For simplicity the composite factor will be assimilated to capital in equations and its remuneration to gross revenue from production.

The initial SAM includes 11 households and we do not proceed to any aggregation since households income are a key indicator for our analysis. To avoid aggregation bias, it is useful to keep households categories as detailed as possible. Households are divided into two categories: urban households (7) and rural ones (4). The 7 urban households are located in Bamako (3) and in other urban areas. Households in Bamako are in the industrial sector, public sector and in private services. This description holds for other urban households. Rural households are in agricultural activities in the three main climatic areas of the country (Sahel and Sahara, Soudano-Sahel and Delta, Soudano-Guinean) and non agricultural ones (other rural activities).

To explicitly describe in detail cotton sectors (seed and fiber) that were aggregated with other agricultural commodities and industrial products in the initial SAM, we have used the shares in a 1997 SAM. Cotton share is relatively stable in agricultural production in Mali and the Supply and Use table that is the core of the 2001 SAM was the one of 1998. We have also introduced firms account from the 1997 SAM. However as one could expect, the above mentioned operations led to an unbalanced SAM. So the initial SAM had to be rebalanced by using an appropriate method.

[4] We ran the simulations on scenarios observed in 2003 and 2004, so a 2001 SAM is not as "old" as it seems to be.

Several balancing methods exist in the literature: least squares, RAS, cross entropy. We implemented the rebalancing with the cross entropy method since it has Bayesian foundations (Zellner, 1988) and is suitable for situations with limited information and measurement errors[5].

4 The CGE model

The model developed in this paper is a single country static general equilibrium model of the type presented in De Melo, Dervis and Robinson (1982), and Lofgren et al. (2002). Except the agricultural sector which will be described later, the model is standard in its structure. Production is modeled as a Leontieff function of aggregate value added and aggregate intermediate inputs. Value added for non agricultural activities is defined as a Cobb-Douglas function of composite labor and composite capital. Composite labor is a CES function of unskilled and skilled labor. Capital is specific to each sector while labor (unskilled and skilled) is mobile.

Households maximize a Stone Geary utility function and consume a composite good with resources coming from factors, the government and the rest of the world. Consumption is allocated across commodities according to a Linear Expenditure System (LES).

On the international markets side, we adopt the small country assumption. Mali is then a price taker in international markets. Domestic and imported commodites are imperfect substitutes and are aggregated by CES function (Armington, 1969). On the same way, production is allocated between domestic sales and exports by a Constant Elasticity of transformation function (CET). The values for elasticities of substitution and of transformation are derived from literature (Annabi et al., 2003). These two parameters are respectively 0.5 and 0.75.[6]

The government receives its income by collecting taxes (direct and indirect taxes) and transfers from the rest of the world. It proceeds with public spending, pays public

[5] This is probaly the case here.

[6] We proceed on next sections to a systemetic sensitivity analysis.

sector workers and makes transfers to households. Public spending are assumed to be exogenous and savings as a flexible residual.

One of the originality of this model resides in the treatment of the agricultural sectors particularly those of maize, millet, and seed cotton. In this sector, instead of working with standard production functions, we try to better represent the Malian reality by considering supply and demand functions which are derived from joint production functions. This approach is inspired by Sadoulet and de Janvry (2002) and allows direct substitution between crops. Agricultural activities (particularly cotton production in Mali) are better characterized by this type of behavior: farmers jointly choose crops and factors as part of a single income strategy (optimization program). Malian cotton growers also do cultivate (Nubukpo and Keita, 2005; Hugon, 2005). We opt for a generalized Leontieff profit function from which we derive supply functions of three crops (cotton, maize and millet) and demand for three factors (unskilled labor, skilled labor and an aggregate input). The system of supply functions is estimated with the technique of seemingly unrelated regressions and, imposing symmetry constraints. Demand elasticities for factors are drawn from the literature, mainly from Sadoulet and de Janvry (2002), who give values for elasticities for different regions of the world. To reconcile these elasticities with those of the supply functions, a least square optimization program is used imposing symmetry.

Demand for factors are estimated at the aggregated level in agriculture so these factors are allocated between sectors according to their share in the total production.

Intermediate inputs used in millet, maize and cotton sectors are treated in a particular way. We opt for a global strategy consisting in aggregating different inputs into an aggregated one. The aggregate intermediate input is allocated between subsectors in accordance with their share in the total production. Aggregate input price is the geometric mean of the prices of different inputs included in. This modeling strategy is not unusual and reduces significantly the number of parameters to be estimated (Fulginiti and Perrin, 1990).

In the model we also take into account home consumption since a large part of food production in Mali is not sold on markets. For example, home consumption represents 70% of maize and millet production. The methodology used is inspired by IFPRI. We assume that, as for marketed commodities, households maximize a Stone-Geary utility function. The resulting LES function is identical for this of marketed commodities excepted that consumption is valuated here at the activity specific producer price (opportunity cost).

Urban-rural migration flows are modeled in an extended Harris-Todaro framework. We assume that working in rural sectors and working in urban ones are imperfect substitutes and that costs are associated to that choice. We take into account this hypothesis by setting the elasticity of migration to 0.5.

The price establishing mechanism mentioned earlier leads to the following modeling framework.

CMDT takes world cotton price as given and pays seed cotton growers after covering its cost of production (labor and intermediate inputs). It makes an advantage of his monopoly power and realizes a margin that allows to remunerate capital and eventually to make a profit. However, as mentioned earlier, a minimum guaranteed price exists and this price will serve as a floor price. So, producers can benefit from an increase in world prices while being guaranteed that they will get at least the floor price. The two cotton price regime resulting is then:

$$p_{\cot g} = \max \left[\overline{p}_{\cot g}, \frac{P_f^w - \sum\limits_{i \epsilon I - \cot g} P_{ci} a_{ij} - \partial_l w}{(1+\theta)} \right]$$

where $p_{\cot g}$ is seed cotton price, P_f^w, world price of cotton fiber, P_{ci}, the unit price of intermediate input i, a_{ij} a technical coefficient, ∂_l, the labor technical coefficient, θ the margin and w aggregate labor wage rate.

Graphically, the relationship between producers' price and world price of lint cotton is a line with a positive slop and a minimum given by the floor price.

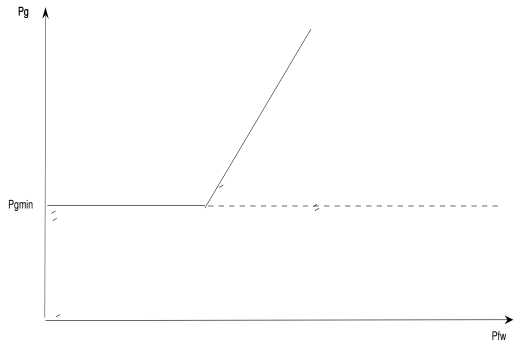

Figure 1

The consequence of the floor price system for CMDT is that it could, given the evolution of its cost of production, make losses (negative profits). In the past, this situation occurred many times. The resulting deficits (15 billion F CFA on average by campaign) were fulfilled by the Malian government through subsidies.

Finally the closure rule adopted is the "classical" one. Total investment is endogenous and adjusts to total savings. Marginal propensities to save are fixed. Nominal exchange rate is fixed and foreign savings flexible.

5 Results

5.1 Macro and sectoral results

All the simulations run consist of increasing the world price of cotton fiber. Three scenarios are run regarding cotton price variation: a low one (5%), a medium one (10%) and a high one (15%). These scenarios are consistent with the results one can find in the literature (Araujo Bonjean et al. 2006) Goreux, 2003).

Table 1: Results

	Sim1 (+5%)	Sim2 (+10%)	Sim3 (+15%)
PRODUCTION			
Maize	-28.4	-28.49	-31.76
Millet	-5.11	-11.21	-16.62
Other food agr. commodities	-0.01	-0.30	-0.02
Seed cotton	6.15	6.90	12.29
Other agricultural commodities	-0.01	-0.11	-0.08
Cotton fiber	6.15	6.90	12.29
Mining products	-20.25	-28.33	-30.80
Other industrial products	-0.25	-4.49	-6.31
Marketable Services	0.07	0.83	0.63
Non marketable services	0.04	0.32	0.68
GDP	**0.13**	**0.27**	**0.58**
EXPORTS			
Other agricultural commodities	-1.05	-4.06	-9.19
Cotton fiber	7.10	8.15	16.26
Other industrial products	-8.80	-1.44	-10

A 5% increase in the world price leads to an aggregate level limited increase of GDP of 0.13%. At sectoral level, the increase in seed cotton production (the main input in fiber production) is detrimental to maize and millet (main competitor of cotton) and to mining commodities. The increase in the relative price of seed cotton leads to a movement of factors from these sectors to seed cotton's. Cotton fiber production increases without surprise by 6.15%. Other sectors production's increase although limited is essentially due to the increase of demand resulting of the improvement of incomes as we will see later.

When it comes to 10% and 15% increase, GDP grows monotonously (0.27 then 0.58%). The preceding results are reinforced. The fiber and seed cotton production which increase by 6.90 then 12,29% is more and more detrimental to cereals. These sharp decreases are essentially due to unskilled labor movements between sectors and to capital movements into agricultural sector. Other sectors are less affected by cotton price increase because they are intensive in skilled labor which is not used in cotton sector.

These results are more significant than those of Boccanfuso and Savard (2007) where no impact has been observed (neither at the aggregate level nor at sectoral level) with an increase of the world price by 50%. The introduction of unemployment at medium term and the introduction of direct substitution possibilities between crops explain these results. For example taking into account the possibility of allocating a fraction of capital or land to other crops reinforce the substitution effects compared to a situation where factors were specific.

According to the scenarios, cotton fiber exports (values) increase by 7 to 16.26%. Exports rise more than production due to the fact that the average producer price (including domestic sales) increases less than the export price.

Exports for other sectors fall sharply due to the fall in production. Exports fall more than production due to relative price effects. Fall in production (with an increase in demand) leads , to an increase of domestic prices and so to a fall in exports. Other industrial products which include gold fall by 10% with the increase of cotton price by 15%. It is then worth noting that the two main exported commodities are in real competition. A boom in one sector could be detrimental to the other one. Probably the rise in export earnings from cotton sector would not compensate losses from gold sector.

5.2 Factors remunerations and income

On the average, the increase of the fiber price leads to an improvement of the unskilled labor wage which is intensively used in the sector. Skilled labor wage also increases but less than unskilled one. This situation is reinforced when the increase in cotton price is important and when the economy approaches full employment.

Table 2: Results (ctd)

	Sim1 (+5%)	Sim2 (+10%)	Sim3 (+15%)
LABOR REMUNERATION			
wage (skilled labor)	0.21	0.45	0.70
wage (unskilled labor)	1.33	2.66	4.00
Households income			
Bamako industrial sector	-0.01	0.07	0.16
Bamako public services	0.03	0.71	1.05
Bamako private sector	0.07	0.90	1.34
Other urbans industrial sector	0.01	0.33	0.55
Other urbans public services	0.08	1.11	1.63
Other urbans private sector	0.12	1.43	2.08
Other urbans	0.03	0.27	0.48
Rurals-Agriculture (Sahel & Sahara)	-0.01	-0.16	-0.14
Rurals-Agriculture(Soudano-Sahel & Delta)	0.11	1.07	1.59
Rurals-Agriculture (Soudano-Guinean)	0.13	1.37	1.99
Other rural activities	0.11	0.87	1.31
Government			
Income	1.68	8.38	12.14
Public savings	9.88	11.09	12.31

Households' income increases according to scenarios by 0.01 to 2.08% except for rural households in Sahel and Sahara regions . Generally, households' income increase monotonously with increased wages. Rural households in Soudano-Sahel & Delta and in Soudano-Guinean regions are those who produce seed cotton. Their income comes in large part from unskilled labor wage and from capital. So they benefit from the improvement of unskilled labor wage. In the same way, urban households benefit from the remuneration of the skilled labor wage and of the fixed urban wage rate for unskilled workers. Households in Sahel & Sahara region do not benefit from positive effects of cotton price increase because of the slight decrease in capital rent in other agricultural food and other agricultural commodities sectors (essentially livestock farming). When it comes to the increase of cotton price by 15% and when the economy approaches full employment, all the above mentioned impacts are reinforced.

The government income increases by 1.68 to 12.14% according to the assumptions. This increase in income is essentially due to the increase in taxes (direct and indirect) on households' income and on consumption and on activities (production). In reality this increase in fiscal revenues is a net effect given that production increases in some sectors while it decreases in others. Finally, given that public spending and other transfers are exogenous, government savings increase more than the income.

To sum up, whatever the privileged scenario, the removal of cotton subsidies will have a positive impact on the Malian economy. This result depends however to the assumptions behind the model and particularly the free parameters values. So we proceed afterwards to a sensitivity analysis on these parameters.

6 Sensitivity analysis

The treatment of parameter uncertainty in general equilibrium modeling hasn't been studied so often in the literature. However the question is crucial given that few parameters are estimated econometrically. Furthermore, impacts one can observe when a policy change is simulated are not monotonous in relation to parameters. The traditional way consisting of varying the values of one parameter or one group of parameters and keeping the others at their base values ignores the possibility of combinations that could yield unexpected results. So it is more convenient to make a systematic sensitivity analysis in order not to "lose" some unexpected results.

The first attempt to face the issue has been performed by Pagan and Shannon (1985). In this paper the authors assess with a linearization technique, the sensitivity of the solutions of a general equilibrium model to parameters that are estimated econometrically. This approach has been resumed then extended by Dufour and Abdelkhalek (1998). It consists of integrating in the model the standard errors of the parameters. In a parallel way, a new method called "systematic sensitivity analysis" emerged under the influence of Harrison and Vinod (1992), Jensen, Rutherford and Tarr (1998) and Abler et al. (1999). This new approach is based on monte carlo experiments. Parameters are treated as random variables drawn from specified distribution in a reasonable range. This range could be the range found in the literature.

We adopt in this paper the systematic sensitivity approach rather than the Pagan-Shanon one. Given that our system of supply and demand in agricultural sector is only partially estimated, we do not have the exact variance covariance matrix of parameters. For each elasticity of substitution and of transformation, we take 100 times a random draw from a uniform distribution within the range found in the literature. We assume that parameters are generated by a uniform distribution to reflect the equiprobability of different values. The ranges for parameters are respectively [0.2,2.4] and [0.4,3] for elasticity of substitution and of transformation. The results for Sim2 and for households' income are presented below[7]

Table 3: Sensitivity analysis results: households' income

	Sim3 (15%)	Lower bound	Upper bound
Bamako industrial sector	0.16	0.01	0.37
Bamako public services	1.05	0.14	1.20
Bamako private sector	1.34	0.32	1.50
Other urbans industrial sector	0.55	0.03	0.76
Other urbans public services	1.63	0.79	1.77
Other urbans private sector	2.08	1.21	2.23
Other urbans	0.48	-0.08	0.70
Rurals-Agriculture (Sahel & Sahara)	-0.14	-1.28	-0.03
Rurals-Agriculture(Soudano-Sahel & Delta)	1.59	0.78	1.74
Rurals-Agriculture (Soudano-Guinéen)	1.99	1.20	2.11
Other rural activities	1.31	0.54	1.45

[7] Other results are available from the author upon request.

Results found in previous sections appear robust when accounting for parameter uncertainty. The ranges of variation are very close to the result found in the base simulation. However, given that we are not in an inference framework, this bands are not treated as confidence ones. Probably a better way to take into account uncertainty would consist of differentiating parameter values according to sectors given that technologies may differ from one sector to another. Results would probably appear more robust but data limitations make this work difficult.

7 Conclusion

The removal of the United States and European Union cotton subsidies are expected to have substantial effects on African economies. These effects appear positive and significant for Mali. The increase in world price that would occur with the removal of subsidies will have a non negligible impact on the economy contrary to previous studies (Boccanfuso and Savard, 2007). GDP will grow by 0.13 to 0.58% and households income will increase significantly by 0.1 to 2%. In the same way, government income will increase significantly as well as public savings.

Sectors that will benefit from cotton price increase are obviously those of seed cotton and fiber. On the opposite, sectors that are substitutes for cotton (essentially cereals) could have a sharp fall in production due to competition for factors use (land and capital). The import bill for these commodities could be huge particularly in period of food crisis. These issues have to be analyzed with care. In the same way, the gold sector may suffer from the boom in cotton sector.

Abler et al. (1999) type systematic sensitivity analysis indicates that the effects are robust to parameter uncertainty. A better way to take into account this parameter uncertainty in the future will consist of assuming different values for parameters for each sector.

The work undertaken in this paper should be continued. Ongoing research should first consist of updating the social accounting matrix. Then the CGE model should be enhanced with a microsimulation model in order to assess distributional issues (poverty and inequality). However this CGE-microsimulation approach raises serious issues such as reconciling national accounts and households surveys (Robilliard and Robinson, 2003).

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A The model

A.1 Sets

I, J = commodities, activities

$AGR(I)$ = agricultural products with supply function

$NAGR(I)$ = other commodities

$M(I)$ = imported countries $\qquad M(I) \subset I$

$NM(I)$ = non imported commodities $\qquad NM(I) \subset I$

$E(I)$ = exported commodities $\qquad E(I) \subset I$

$NE(I)$ = non exported commodities $\qquad NE(I) \subset I$

F = factors

H = households

A.2 Parameters

a_j : quantity of value-added per production unit

b_j : quantity of input per production unit

A_j : efficiency parameter in the value-added function

A_j^L : efficiency parameter in the composite labor function

k_{mig} : efficiency parameter in the migration equation

δ_j^k : share parameter for capital in the value-added function

$\delta_j^{\ln q}$: share parameter for unskilled labor in the composite labor function

ρ_j : value-added function exponent

σ_j : elasticity of substitution between capital and composite labor

σ_{mig} : elasticity of migration

γ_{ij} : quantity of commodity i as intermediate input per unit of production j

α^{cot} : intercept of the cotton supply function

α^{mil} : intercept of the millet supply function

α^{maize} : intercept of the maize supply function

β_{cot}^{mil} : coefficient of the price of millet relatively to cotton price

β_{maize}^{mil} : coefficient of the price of millet relatively to the price of maize

$\beta_{\text{cot}}^{maize}$: coefficient of the price of maize relatively to cotton price
β_{mil}^{maize} : coefficient of the price of maize relatively to millet price
β_{mil}^{cot} : coefficient of the price of cotton relatively to millet price
$\beta_{maize}^{\text{cot}}$: coefficient of the price of cotton relatively to the price of maize
ζ_{cot}^{nq} : coefficient of the real wage of unskilled labor in the cotton supply function
ζ_{mil}^{nq} : coefficient of the real wage of unskilled labor in the millet supply function
ζ_{cot}^{q} :coefficient of the real wage of skilled labor in the cotton supply function
ζ_{mil}^{q} : coefficient of the real wage of skilled labor in the millet supply function
ρ_{cot}^{k} : coefficient of capital in the cotton supply function
ρ_{mil}^{k} : coefficient of capital in the millet supply function
η^{nq} : intercept of the unskilled labor demand function
η^{q} : intercept of the skilled labor demand function
$\eta^{I_{ag}}$: intercept of composite input demand function
ξ_{j}^{nq} : coefficient of the ratio price/wage in the unskilled labor demand function
ξ_{L}^{nq} : coefficient of the relative wage in the unskilled labor demand function
$\xi_{I_{ag}}^{nq}$: coefficient of the ratio composite input price\unskilled labor wage
$\xi_{I_{ag}}^{q}$: coefficient of the ratio composite input price\skilled labor wage
ρ_{k}^{nq} : coefficient of capital in the unskilled labor demand function
ξ_{j}^{q} : coefficient of the ratio prices/wages in the skilled labor demand function
ξ_{L}^{q} : coefficient of the relative wages in the skilled labor demand function
ρ_{kj}^{q} : coefficient of capital in the skilled labor demand function
$\xi_{j}^{I_{ag}}$: coefficient of the ratio products prices\composite input price
$\xi_{q}^{I_{ag}}$: coefficient of the ratio skilled labor wage\composite input price
$\xi_{nq}^{I_{ag}}$: coefficient of the ratio unskilled labor wages\composite input price
$\rho_{k}^{I_{ag}}$: coefficient of capital in the composite input demand function
B_{c}^{t} : efficiency parameter in the composite production (CET) function
B_{i}^{o} : efficiency parameter in the armington function
δ_{i}^{t} : CET function share parameter
ρ_{i}^{t} : CET function exponent
σ_{t} : constant elasticity of transformation
δ_{i}^{o} : armington function share parameter

υ_i : share of product i in the composite input

ρ_i^o : Armington function exponent

σ_c : Constant elasticity of substitution

t_i : tax rate for activity i

t_m : import tariff rate

t_e : export tax rate

tx : indirect taxes

t_{ent} : tax rate on Firms income

ω_h^L : share of income of aggregate labor for household h

ω_h^K : share of income of capital for household h

Π_h : share for household h in transfers

PME_h : marginal propensity to save for household h

td_h : direct tax rate for household h

β_i^h : marginal share of consumption spending on marketed i for household h

β_{ih}^{auto} : marginal share of consumption on home commodity i for household h

ϕ_i : share for the commodity i in total investment

Θ_L^w : share for the rest of the world in labor income

Θ_K^w : share for the rest of the world capital income

θ : margin rate for the textile industry (CMDT)

A.3 Endogenous variables

X_j : production for activity j

VA_j : quantity of value-added for activity j

CI_j : total intermediate input for activity j

L_j : aggregated labor

L_j^{nq} : quantity demanded of unskilled labor from activity j

L_j^q : quantity demanded of skilled labor from activity j

$\overline{K}_{AG}$: quantity demanded of capital from agricultural activities (millet, maize, cotton)

CI_{ij} : demand of intermediate input i by activity j

I_{ag} : aggregate input in agricultural sectors (millet, maize, cotton).

I_{ag}^{j} : quantity demanded of aggregate input from agricultural activity j

$QCOM_i$: quantity of marketed output of commodity i

$Q_{i\,h}^{auto}$: quantity of households home consumption of commodity i for household h

QE_i : quantity of exports

QD_i : quantity sold domestically of domestic output

QM_i : quantity of imports

QT_{serv} : production of trade and transport margins

$QARM_i$: composite supply

P_i^e : export price in domestic currency

P_i^m : import price in domestic currency

P_i^d : consumer price for the domestic commodity (demand price)

P_i^p : producer price for the domestic commodity (supply price)

P_{ci} : composite commodity price

$P_{cI_{ag}}$: aggregate input price

P_i : average price for activity i

P_{VA}^{j} : value-added price

r_j : price of capital in activity j

R_A :price of capital agricultural sectors (millet, maize, cotton)

EBE_{AG} : gross profit in agriculture

w_j : wage rate in activity j

w_{nq} : average wage rate (unskilled labor)

W_{nq}^{A} : average wage rate of unskilled labor in agriculture

W_{nq}^{U} : average wage rate of unskilled labor in urban sectors

W_{nqu}^{e} : expected wage rate in urban sectors.

w_q : average wage rate of skilled labor

YHF_h : income of factors for household h

YH_h : total income for household h

YD_h : disposable income for household h

SAV_h : households savings

SE : firms savings

YE : firms revenue

Q_i^h : quantity consumed of commodity i by household h

INV_i : investment in commodity i

μ_i : value of trade margins

$INVTOT$: value of total investment

$TRANSGOVTOT$: total of government transfers to households

$C\text{hom}$: unemployment

$\overline{FSAV}$: foreign savings

$GSAV$: government savings

$\overline{L^{nq}}$: total quantity of unskilled labor

A.4 Exogenous variables

$\overline{K_j}$: quantity demanded for capital in activity j

$\overline{K}$: total quantity supplied of capital

$\overline{K}_{AG}$: total quantity supplied of capital in agriculture

$\overline{L^q}$: total quantity supplied of skilled labor

$\overline{P_{ei}^w}$: export price (foreign currency)

$\overline{P_{mi}^w}$: import price (foreign currency)

e^* : exchange rate (local currency per unit of foreign currency)

$\overline{CONSG}$: government expenditures

$\Delta STOCK_i$: stock change

$TRANS^{RDM}$: transfers from the rest of the world to the government

$TRANS_h^{RDM}$: transfers from the rest of the world to households

DIV_h : dividends paid by firms to households

$TRANS_E^{RDM}$: transfers from firms to the rest of the world

$TRANSGOV_h$: transfers from the government to households

Production block

1. $X_j = \min\left[\frac{VA_j}{a_j}, \frac{CI_j}{b_j}\right]$ $\qquad j \in NAGR(j)$

2. $X_{\text{cot}} = \alpha^{\text{cot}} + \beta_{\text{cot}}^{mil}\left(\frac{P_{mil}^{i}}{P_{\text{cot}}}\right)^{\frac{1}{2}} + \beta_{\text{cot}}^{maïs}\left(\frac{P_{maïs}^{i}}{P_{\text{cot}}}\right)^{\frac{1}{2}} \zeta_{\text{cot}}^{nq}\left(\frac{w_{nqa}}{P_{\text{cot}}}\right)^{\frac{1}{2}} + \zeta_{\text{cot}}^{q}\left(\frac{w_{q}}{P_{\text{cot}}}\right)^{\frac{1}{2}}$

$+\zeta_{\text{cot}}^{I_{ag}}\left(\frac{P_{cI_{ag}}}{P_{\text{cot}}}\right)^{\frac{1}{2}} + \rho_{\text{cot}}^{k}K$

3. $X_{mil} = \alpha^{mil} + \beta_{mil}^{\text{cot}}\left(\frac{P_{\text{cot}}^{i}}{P_{mil}^{p}}\right)^{\frac{1}{2}} + \beta_{mil}^{maïs}\left(\frac{P_{maïs}^{i}}{P_{mil}}\right)^{\frac{1}{2}} \zeta_{mil}^{nq}\left(\frac{w_{nqa}}{P_{mil}}\right)^{\frac{1}{2}} + \zeta_{mil}^{q}\left(\frac{w_{q}}{P_{mil}}\right)^{\frac{1}{2}}$

$+\zeta_{mil}^{I_{ag}}\left(\frac{P_{cI_{ag}}}{P_{mil}}\right)^{\frac{1}{2}} + \rho_{mil}^{k}\overline{K}_{AG}$

4. $X_{maïs} = \alpha^{maïs} + \beta_{maïs}^{\text{cot}}\left(\frac{P_{\text{cot}}}{P_{maïs}^{p}}\right)^{\frac{1}{2}} + \beta_{maïs}^{mil}\left(\frac{P_{mil}}{P_{maïs}}\right)^{\frac{1}{2}} \zeta_{mais}^{nq}\left(\frac{w_{nqa}}{P_{mais}}\right)^{\frac{1}{2}} + \zeta_{mais}^{q}\left(\frac{w_{q}}{P_{mais}}\right)^{\frac{1}{2}}$

$+\zeta_{mais}^{I_{ag}}\left(\frac{P_{cI_{ag}}}{P_{mais}}\right)^{\frac{1}{2}} + \rho_{mais}^{k}\overline{K}_{AG}$

5. $-L_{AG}^{q} = \eta^{q} + \sum_{i}\xi_{i}^{q}\left(\frac{P_{i}}{w_{q}}\right)^{\frac{1}{2}} + \xi_{L}^{q}\left(\frac{w_{nq}}{w_{q}}\right)^{\frac{1}{2}} + \xi_{I_{ag}}^{q}\left(\frac{P_{cI_{ag}}}{w_{q}}\right)^{\frac{1}{2}} + \rho_{k}^{q}\overline{K}_{AG}$

6. $-L_{AG}^{nq} = \eta^{nq} + \sum_{i}\xi_{i}^{nq}\left(\frac{P_{i}}{w_{nqa}}\right)^{\frac{1}{2}} + \xi_{L}^{nq}\left(\frac{w_{q}}{w_{nqa}}\right)^{\frac{1}{2}} + \xi_{I_{ag}}^{nq}\left(\frac{P_{cI_{ag}}}{w_{nqa}}\right)^{\frac{1}{2}} + \rho_{k}^{nq}\overline{K}_{AG}$

7. $-I_{ag} = \eta^{I_{ag}} + \sum_{i}\xi_{i}^{I_{ag}}\left(\frac{P_{i}}{P_{cI_{ag}}}\right)^{\frac{1}{2}} + \xi_{q}^{I_{ag}}\left(\frac{w_{q}}{P_{cI_{ag}}}\right)^{\frac{1}{2}} + \xi_{nq}^{I_{ag}}\left(\frac{w_{nqa}}{P_{cI_{ag}}}\right)^{\frac{1}{2}} + \rho_{k}^{I_{ag}}\overline{K}_{AG}$

8. $I_{ag} = \frac{\sum_{i}\sum_{j}P_{ci}CI_{ij}}{P_{cI_{ag}}} \qquad j \,\epsilon\, AGR(j)$

9. $L_{j}^{nq} = \left[\frac{L_{j}^{nqo}}{L_{AG}^{nqo}}\frac{\sum X_{j}^{o}}{X_{j}^{o}}\right]\frac{X_{j}}{\sum X_{j}}L_{AG}^{nq} \qquad j \,\epsilon\, AGR(j)$

10. $L_{j}^{q} = \left[\frac{L_{j}^{qo}}{L_{AG}^{qo}}\frac{\sum X_{j}^{o}}{X_{j}^{o}}\right]\frac{X_{j}}{\sum X_{j}}L_{AG}^{q} \qquad j \,\epsilon\, AGR(j)$

11. $I_{ag}(j) = \left[\frac{\sum_{i}P_{ci}^{o}CI_{ij}^{o}}{\sum_{i}\sum_{j}P_{ci}^{o}CI_{ij}^{o}}\frac{\sum X_{j}^{o}}{X_{j}^{o}}\right]\frac{X_{j}}{\sum X_{j}}I_{ag} \qquad j \,\epsilon\, AGR(j)$

12. $P_{cI_{ag}} = \prod_{i}P_{ci}^{\upsilon_{i}}$

13. $\upsilon_{i} = \frac{\sum_{j}P_{ci}CI_{ij}}{\sum_{i}\sum_{j}P_{ci}CI_{ij}}$

14. $VA_{j} = a_{j}.X_{j} \qquad j \in NAGR(j)$

15. $CI_j = b_j.X_j$

16. $VA_j = A_j \left[\delta_j^k.\overline{K_j^{-\rho_j}} + (1-\delta_j^k)L_j^{-\rho_j}\right]^{-\frac{1}{\rho_j}}$ $\quad j \in NAGR(j)$

17. $L_j = A_j^L (L_j^{nq})^{\delta_j^{\ln q}} (L_j^q)^{(1-\delta_j^{\ln q})}$ $\quad j \in NAGR(j)$

18. $\frac{\overline{K_j}}{L_j} = \frac{\delta_j^k}{1-\delta_j^k}\frac{w_j}{r_j}$ $\quad j \in NAGR\,(j)$

19. $\frac{L_j^{nq}}{L_j^q} = \frac{\delta_j^{\ln q}}{1-\delta_j^{\ln q}}\frac{w_q}{w_{nqj}}$

20. $L_j = A_j^L \left[\delta_j^{\ln q}.\left(L_j^{nq}\right)^{-\rho_j} + \left(1-\delta_j^{\ln q}\right)(L_j^q)^{-\rho_j}\right]^{-\frac{1}{\rho_j}}$

21. $\frac{L_j^q}{L_j^{qn}} = \left[\frac{1-\delta_j^{\ln q}}{\delta_j^{\ln q}}\frac{w_{nq}}{w_q}\right]^{\sigma_j}$

22. $X_f = X_g$

23. $L_f = \partial_l X_f$

24. $CI_{ij} = \gamma_{ij} CI_j$ $\quad j \in NAGR(j)$

25. $QCOM_i + \sum_h Q_{i\,h}^{c\,auto} = X_i$

26. $QCOM_i = B_c^t[\delta_i^t.QE_i^{-\rho_i^t} + (1-\delta_i^t)QD_i^{-\rho_i^t}]^{-\frac{1}{\rho_i^t}}$ $\quad i \in E(I)$

27. $\frac{QD_i}{QE_i} = \left[\frac{P_i^e}{P_i^p}.\frac{1-\delta_i^t}{\delta_i^t}\right]^{\sigma_t}$ $\quad i \in NE(I)$

28. $QCOM_i = QD_i$ $\quad i \in NE(i)$

29. $QARM_i = B_i^o[\delta_i^o.QM_i^{-\rho_i^o} + (1-\delta_i^o)QD_i^{-\rho_i^o}]^{-\frac{1}{\rho_i^o}}$ $\quad i \in M(I)$

30. $\frac{QM_i}{QD_i} = \left[\frac{P_i^d}{P_i^m}.\frac{\delta_i^o}{1-\delta_i^o}\right]^{\sigma_c}$ $\quad i \in M(I)$

31. $QARM_i = QD_i$ $\quad i \in NM\ (I)$

32. $QT_{serv} = \sum_i \mu_i$

33. $r_j = \frac{P_{VA}^{j} VA_j - w_j.L_j}{\overline{K}_j}$ $\qquad j \in NAGR(j)$

34. $EBE_A = \sum p_j X_j - w_{nqA}.L_{AG}^{nq} - w_q.L_{AG}^{q} - P_{cI_{ag}} * I_{ag}$ $\qquad j \in AGR(j)$

35. $EBE_A = r_A.\overline{K}_{AG}$

36. $w_j = \frac{w_{nqj}.L_j^{nq} + w_q.L_j^q}{L_j}$

37. $\theta ppX_f = r_f * K_f$

38. $W_{nqu}^e = \left[\frac{\sum\limits_{j \epsilon U(j)} L_j^{nq}}{\sum\limits_{j \epsilon U(j)} L_j^{nq} + C\,\mathrm{hom}} \right] W_{nqu}$

39. $\left[\frac{\sum\limits_{j \epsilon AG(j)} L_j^{nq}}{\sum\limits_{j \epsilon U(j)} L_j^{nq}} \right] = k \left[\frac{W_{nqa}}{W_{nqu}^e} \right]^{\sigma_{mig}}$

Price block

40. $p_{\cot g} = \max \left[\overline{p}_{\cot g}, \frac{P_f^w - \sum\limits_{i \epsilon I - \cot g} P_{ci} a_{ij} - \partial_l w}{(1+\theta)} \right]$

41. $P_i^e = \overline{P_{ei}^w} \left(1 - t_e\right).e^*$

42. $P_i^m = \overline{P_{mi}^w} \left(1 + t_m\right) (1 + tx).e^*$

43. $P_i^d = P_i^p (1 + tx)$

44. $P_{ci} = \frac{P_i^d.QD_i + P_i^m.QM_i + \mu_i}{QARM_i}$

45. $P_i = \frac{P_i^p.QD_i + P_i^e.QE_i}{QCOM_i}$

46. $P_j(1 - t_j).X_j = P_j^{va}.VA_j + \sum\limits_i P^i.CI_{ij}$ $\qquad j \in NAGR(j)$

Institutions blocs

47. $YHF_h = \omega_h^{L_{nq}} \left[\sum_j w_{nqj}.L_j^{nq} \right] + \omega_h^{L_q} \left(\sum_j w_q.L_j^q \right) + \omega_h^K \left(\sum_j r_j.\overline{K_j} \right)$

48. $YH_h = YHF_h + TRANSGOV_h + TRANS_h^{RDM} + DIV_h$

49. $TRANSGOV_h = \Pi_h.TRANSGOVTOT$

50. $YD_h = (1 - PME_h).(1 - td_h).YH_h$

51. $SAV_h = \; PME_h(1 - td_h)YH_h$

52. $YE = \left(1 - \sum_h \omega_h^K - \Theta_K^w \right) \left(\sum_j r_j.\overline{K_j} \right)$

53. $SE = YE\,(1 - t_{ent}) - \sum_h DIV_h - TRANS_E^{RDM}$

54. $P_{ci}Q_i^h = P_{ci}Q_i^{\min} + \beta_i^h (YD_h - \sum_{i'} P_{ci}Q_{i'}^{\min} - \sum_{i'} P_i.Q_{i'h}^{auto\min})$

55. $P_iQ_{ih}^{auto} = P_iQ_{ih}^{auto\ \min} + \beta_{ih}^{auto}(YD_h - \sum_{i'} P_{ci}Q_{i'}^{\min} - \sum_{i'} P_i.Q_{i'h}^{auto\min})$

56. $INV_i = \frac{\phi_i IINVTOT}{P_{ci}}$

57. $YG = \sum_{h\in H} td_h.YH_h + \sum_{i\in I} tx.\left[P_i^p.QD_i + (1+t_m)\,\overline{P_m^w}.QM_i.e^* \right] + \sum_{i\in I} t_i P_i^p.X_i$
$+ \sum_{i\in M} t_m.\overline{P_m^w}.QM_i.e^* + \sum_{i\in E} t_e.\overline{P_e^w}.QE_i.e^* + \sum_{i\in I} t_i^{cons}.P_i^p.QD_i + TRANS^{RDM}.e^* +$
$t_{ent}YE$

58. $\overline{CONSG} = \sum_i P_{ci}CONSG_i$

equilibrium block

59. $\sum_j L_j^{nq} + C\,\mathrm{hom} = \overline{L^{nq}}$

60. $\sum_j L_j^q = \overline{L^q}$

61. $\sum_{j} \overline{K_j} + \overline{K}_{AG} = \overline{K}$

62. $QARM_i = \sum_{j} CI_{ij} + CI_{iAG} + C + CONSG_i + \sum_{h} Q_i^h + INV_i + \Delta STOCK_i$

63. $QARM_{serv} = \sum_{j} CI_{serv}^j + CONSG_{serv} + \sum_{h} Q_{serv}^h + INV_{serv} + \Delta STOCK_{serv} +$

QT_{serv}

64. $e^*. \sum_{i \in M(I)} \overline{P_{mi}^w}.QM_i + \Theta_{L_{nq}}^w.\sum_{j} w_{nq}(j).L_j^{nq} + \Theta_{L_q}^w.\sum_{j} w_q.L_j^q + \Theta_K^w. \left[\sum_{j} r\,(j)\,.\overline{K_j}\right] +$

$TRANS_E^{RDM} = e^*. \sum_{i \in E(I)} \overline{P_e^w}.QE_i + TRANS_N^{RDM} + \overline{FSAV}$

65. $YG = \overline{CONSG} + \sum_{h} TRANSGOV_h + GSAV$

66. $\sum_{h} PME_h(1 - td_h)YH_h + GSAV + \overline{FSAV} + ESAV = INVTOT$

$+ \sum_{i} P_{ci}.\Delta STOCKS_i$