Increasing Cotton Farmers Incomes in Mali West Africa: Eliminate Subsidies in Developed Countries or Productivity Increase in Mali?

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Abstract

In a WTO battle and the press the argument is often made that eliminating US cotton subsidies would have a large effect on the incomes and competitive position of farmers in developing countries. In Francophone West African cotton production productivity has stagnated after rapid gains in the first two decades after independence (1960-1980). Constructing a farm model based upon farmers' definition of their decision making framework we compare the effects of the elimination of US subsidies with various productivity increasing measures for cotton and diversification in Mali. In the farm model we take into account the elasticity of transmission of a change in the world cotton price to the farm gate price. The gains to eliminating US subsides are very small unless the transmission elasticities of world cotton price to the farm gate price are substantially increased. In contrast the various technological alternatives including Bt cotton introduction, the use of higher and more regionally defined fertilization levels for cotton, and the introduction of a new technology and marketing package for sorghum all have substantially higher returns for the cotton farmers in the West African site of Dioila, Mali. Even with substantial improvement in the mechanisms enabling farmers to benefit from the higher prices of the elimination of US subsidies, there are still much higher returns to the various types of productivity increases. Maybe West Africa needs to act more now on increasing their productivity as protracted trade negotiations continue.

1. Introduction and Background

In the twenty years after independence in 1960 cotton was a successful driver of development in Mali and in cotton producing countries of West Africa. The cotton model was an agricultural model that was set as an example for a wider development strategy. Cotton farmers enjoyed higher incomes, access to better schools, and healthcare relative to non-cotton farmers (SWAC-OECD, 2005). Since the mid 1980's this has not been the case. The cotton industry started to face a deterioration of the terms of trade for cotton; the para-statal ginning sector started to cut back on social services and began transferring back to farmers more of the costs of production as they eliminated input subsidies. Presently the cotton sector is no longer the Malienne model for development. Some even discuss cotton disappearing from the product mix in the best agricultural zones.

The current situation has led policy makers within Mali and outside the region to argue that subsidies to cotton production activities, in the Developed World and the United States in particular, are responsible for the decreasing terms of trade of the West African cotton sector and the deterioration of social conditions for farmers (Goreux, 2003, 2004, 2005; Watkins and Sul, 2002; Alston et al. 2007). These studies have estimated the impact of the removal of US subsidies on the world cotton price (Sumner, 2003, 2006 and Alston et al. 2007). But these same studies have ignored how much of the world price gets actually passed through to farmers and thus assume that increases in world cotton prices would be received by farmers.

Others have argued that it is necessary for Mali to undertake deep reforms in their industry model in order to better respond to current market conditions (Pursell, 1998; Badiane et al., 2002; and Tschirvley, 2007). The theory of structural adjustment is that by transitioning from a para-statal industry model, the competitiveness of the cotton sector would increase and benefit farmers with better prices.

A third approach for attacking the low income problem of cotton farmers is the renewal of the rapid technological progress of the 1960-1980 period. The benefits to productivity improvements in West Africa and Mali have been highlighted before (i.e. Anderson and Valenzuela, 2006 and Vitale et al., 2007) but mainly focused on Bt Cotton. Besides Bt cotton improving soil fertility and technological improvements in other crops are both alternatives to consider for the cotton zone.

Our study evaluates the effects on farm-household income of removing cotton subsidies, changing the industry model, and the introduction of technological change in cotton and alternative crops. The effects on household income of a change in world cotton price focuses upon how much of a change in the world price would be received by farmers. In terms of a change in the industry model we evaluate the effects of farmers becoming owners of the ginning sector in Mali as it has been done elsewhere in West Africa. When evaluating the effects of technological change the production technology alternatives considered are fertilized sorghum production (for farmers diversifying away from cotton), increased fertilization in conventional cotton, and Bt Cotton.

Organization of the Study and Proposed Methodology

The remainder of the paper proceeds as follows. First we discuss the industry structure and the price mechanism that sets farm gate prices using a lagged regression model. Our objective in this section is to evaluate the effects of a change in world cotton prices on farm gate price by establishing the transmission coefficients of the latter to the former. In this same section and using the same regression model we discuss the effects on farm gate prices of farmers gaining shares in the ginning sector. To evaluate the effects on household income of a change in world prices we discuss the farmer decision making mechanism based upon our field work in section three. This decision making framework is incorporated into a linear programming model based upon a utility function representing lexicographic preferences. In section four we formally introduce the linear programming model used to represent our representative farm household. In section five, we analyze the impact on household income of increasing world cotton prices and a change in the cotton industry structure. In section six, we follow our discussion with a description of possible alternatives based on local research to improving productivity. We analyze the diversification away from cotton into improved technology sorghum and of increasing productivity of cotton. When considering cotton production improvements we first consider higher fertilizer dosages and then Bt Cotton. We finish this section by contrasting the effects on household income of changes in world cotton prices to productivity improvements. In section seven we discuss the policy implications of our results.

2. The Cotton Industry Structure in Mali and Farm Gate Price Mechanisms

The cotton sector in Mali is composed of a single ginning company the Malienne Company for Fiber Development or CMDT for its French acronym. The CMDT is vertically integrated and provides farmers various supporting operations required to produce cotton such as necessary inputs, research and extension, and transportation of seed cotton to the gins. In Mali the CMDT is the sole exporter of the cotton lint to the world market. Also as the sole ginner of cotton it has monopsony power in the negotiation of seed cotton prices. In Mali the state holds an interest of 60 percent in CMDT and the French para-statal Dagris controls the remaining shares.

At the end of 2008 Mali is expected to begin to privatize the cotton sector. The Malian privatization schedule foresees the creation of 3 companies in which the state will retain a minority role. Farmers groups will also be eligible to own part of the stocks of the new companies. As in the rest of West Africa, the cotton reform process in Mali has pursued two key policy aspects: (i) privatization, reducing the ownership and direct control of the public sector to increase the efficiency and transparency of the agricultural sector and (ii) better price incentives by aligning local and producer prices with world market prices (i.e. Badiane et al., 2002 and Tschiverly, 2007). But despite privatization, the effects of price competition between gins that could ultimately result in better prices for farmers are expected to be reduced by the industry model chosen. As in Burkina Faso, Mali has chosen to establish regional monopolies for the three new companies created. With regards to seed cotton pricing it is foreseen that the pan-territorial pricing policy, in place for more than 20 years, will be kept in place and farmers will receive the same price irrespective of the company they are selling to (Office of the Prime Minister, 2007).

The pan-territorial policy has also maintained the price setting mechanism in place. Prices are set through negotiations between CMDT and the national representation of farmers groups in Mali. However, farmers' ability to negotiate product prices is limited by two factors: (i) the strength of negotiating power of their representatives and (ii) government legislation that governs the floor and ceiling of prices (Nubkpo and Keita, 2005). Legislatively, the government of Mali in the last three years since 2005, has set the floor price for seed cotton at 0.32 US$/Kg and its ceiling at 0.35 US$/Kg. Prices are set before planting or no later than a month after planting. The ginner CMDT will sell that same cotton 4 to 5 months after harvest, which starts in December. If world market prices increase to a sufficient degree that the ginner has excess profits, there is also a legislated mechanism to distribute part of those profits back to farmers in the form of second payments.

As is clear from this market structure not all of the variation in the world cotton price will necessarily be transferred back to farmers in their farm gate price. It is the ginning sector not farmers, who take the short term risk of price variation in the cotton world market. The ginning sector is only able to adjust farm gate prices to variations in the world cotton price with a lag (of almost a year) during their negotiations at the beginning of a new production season.

Evaluating Changes in Farm Gate Prices to Changes in the World Cotton Price

Most studies have focused on the effects of the elimination of cotton subsidies in the US on world cotton price and supply (Sumner 2003, 2006 and Alston and Brunke, 2006). Under the given industry structure and price mechanism we focus on the changes in the farm gate cotton price received by farmers given a change in the world price in Mali. We first estimate the elasticities[1] of transmission of the world cotton price back to the farm gate price for seed cotton. Once these elasticities have been obtained we then evaluate the effects of a change in world cotton prices on farm gate prices. We use a lagged regression model to characterize the price mechanism that sets the farm gate price. As highlighted previously the ginning sector only adjusts farm gate prices with a lag. The farm gate price is not affected by current period variations of the world cotton price. Therefore our specification does not include the effects of the current world cotton price. In equation 1, below we present our model specification:

[1] Alston et al., (2007) in a first attempt to characterize the impact of a change in the world price of cotton back to the household uses the transmission elasticity of US cotton price to West Africa price at the county level and not at the farm gate price. Even though this study clearly describes the cotton industry structure in West Africa, along with the price mechanism that sets farm gate prices, does not provide an empirical model that characterize it or the transmission of world cotton prices back to the farm gate price.

$$P_t^f = \alpha + \beta_1 P_{t-1}^w + \beta_2 P_{t-1}^f + \theta Def + \delta t + \varepsilon_t \quad [1]$$

Where: P_t^f, Seed Cotton Farm Gate Price; P_{t-1}^w, Lagged Seed Cotton Equivalent World Price; P_{t-1}^f, Lagged Seed Cotton Farm Gate Price; Def, GDP Deflator; t, Time trend. In our model the parameter on the lagged world cotton price represents the degree of transmission of changes in world cotton prices to the farm gate price. It is lagged given that under the price mechanism that sets prices in Mali, farm gate prices only adjust with a lag. We also include the effects of the lagged own farm gate price in our model. In Mali, as in much of West Africa, farm gate prices are kept frozen from one season to another and thus farmers' price expectations are usually built around the previous period prices. The inclusion of the GDP deflator is to account for potential inflation effects. We also include time to account for trends in the data.

For world prices we use the Cotton A index price, which is the world reference cotton price, obtained from Cotlook reported in US$/Lb which we have transformed to US$/Kg. We use a price series from 1970 to 2006. World cotton prices are transformed to their seed cotton equivalent FOB value in local currency. To accomplish this we first deflate world cotton prices by the relative value of CIF to FOB cost as reported by Baffes (2007). This accounts for transport costs and gives us a proxy for the world price at the ginners' gate or FOB price. It does not account for ginning cost or any degree of market power the ginning sector has in Mali. We then deflate prices further by the ginning efficiency ratio for Mali to determine a seed[2] cotton equivalent price which is multiplied by the relevant exchange rate for each particular year as reported by the World Bank. For the farm gate price we use the official prices reported by CMDT for the same period as world cotton prices. Farm gate prices are denominated in local currency per kilogram. The model in equation 1 is estimated in natural logs.

[2] The world cotton price is reported in US$ per pound of lint. Lint is the final results of the ginning process of seed cotton that farmers produce. This deflation allows to compare both prices at a one to one level, as both are denominated is seed cotton terms.

We find that given an increase in the world price of cotton only 21 percent of that increase gets transmitted back to farm gate prices[3] with a lag (Table 1). Other significant effects are a positive time trend and inflation. The significant parameter on the deflator suggests that the adjustment of farm gate prices to inflation is higher than the effects of changing world prices.

Table 1. Price Transmission Elasticities of the World Cotton Price back to the Cotton Farm Gate Price in Mali.

	Coefficients	*Standard Error*	*t Stat*	*P-value*
β_1	0.21	0.06	4.77	0.001
β_2	-0.01	0.17	-0.07	0.947
θ	0.64	0.15	4.26	0.000
δ	0.01	0.01	2.39	0.023
α	0.29	0.29	0.99	0.331

Note: n=37; Adj-R^2: 0.98;ADF: -4.19**; ***: (Pr<0.01). DW:1.73.

Using the model in equation 1 we forecast the farm gate price for seed cotton in the 2007/08. The model suggests that the farm gate price for 2007/08 should have been 0.35 US$/Kg, this is 0.03 US$/Kg higher than the official price of 0.32 US$/kg. Even though our model has overestimated the farm gate price, the estimate is still within the range of the legislated price band set by the Malienne government.

[3] Baffes (2007) using the current period world cotton price and not its lag, finds no link between the world price and farm gate price for cotton in Mali. We on the other hand do find a link between world and farm gate prices for cotton. It occurs with a lag. The lack of such a link in the specification used by Baffes (2007) is due to misspecification of the model.

Having established a model that characterizes the price mechanism that sets farm gate prices, we evaluate the impact on farm gate prices of the removal of subsidy programs for cotton in the US. Many studies have quantified the degree of increases in the world cotton price from a total removal of cotton subsidies in the US. FAO (2004), in a summary of these studies finds an average increase of world cotton prices of 15 percent with a minimum of 2 percent and a maximum of 30 percent. Sumner (2006), in a study that formed part of Brazil's case against US subsidies in the WTO, found that from the removal of all subsidy programs in the US, prices would have increased almost 14 percent. His estimate is close to the average found by the FAO (2004) study. Given the closeness of both estimates we take the FAO (2004) estimation for our work as it is based on a summary of different studies and procedures. We reforecast the 2007/08 farm gate price by increasing the 2006/07 world cotton price by 15 percent. The price in 2006/07 was 1.29 US$/Kg we increase it to 1.48 US$/Kg (Table 1). The model predicts an increase in farm gate price of 2.93 percent to 0.36 US$/Kg for seed cotton. This would have meant that official prices would have only increased to 0.33 US$/Kg or one cent from their level in the 2007/08 season if subsidies had been removed in the previous year.

Table 1. Effects on Farm Gate Prices in Mali due to the Elimination of US Subsidy Programs

	World Price	Farm Gate Price	
	US$/Kg		
		Model	Observed
Base	1.29	0.35	0.32
Change in Prices	1.48	0.36	0.33
Relative Change (%)	15	2.93	

Note: The estimate of the relative change in world cotton prices was taken from the estimate reposted by (2004). Exchange rate for 2007: 1 US$= 498 FCFA (Oanda Corporation, 2008).

Modifying the Industry Structure: Effects on Farm Gate Prices

In the privatization roadmap for the ginning sector, as in other countries in West Africa[4], it is foreseen that part of the gins will be sold to farmers groups (Office of the Prime Minister of Mali, 2006). This same strategy has been followed in Burkina Faso and Senegal and is planned in Benin. The Malienne government and the Bilateral and Multilateral institutions, that are running the privatization program, hope that this would not only increase the degree of responsibility of farmers in the sector but also their negotiating power and hence farm gate prices. In our study we assume that an increase in negotiating power would translate into a higher transmission coefficient of world cotton prices. Given that pan-territorial and pan-seasonal prices will not be undone with privatization our model does not require modification.

To establish by how much the transmission coefficient could increase with farmers having a greater negotiating power we estimate our model in equation 1 for Burkina Faso, Senegal, and Benin. We then test how different their coefficients are to our regression for Mali using the Chow F-statistic. We consider Benin in this procedure because it has a very well developed farmers' organization, despite the fact that farmers do not yet own shares of the gins. These three countries have the same pricing mechanisms as Mali and their industry structure is more or less the same (Baquedano et al, 2008).

The estimates for the transmission coefficients for Benin and Burkina Faso are higher than in Mali (Table 3). In Burkina Faso 33 percent of a one percent increase in the world cotton price gets transmitted back to the farm gate price. In contrast in Benin, only 23 percent of a change in the world cotton price gets transmitted back to the farm gate price (Table 2). The coefficient on the lagged world price in Senegal though is not significantly different than zero.

[4] The other countries in West Africa and have followed or plan to follow this approach are Benin, Burkina Faso, and Senegal.

Table 2. Transmission Coefficients of a Change in World Cotton Prices on Farm Gate Prices in 4 West African Countries.

	Benin	Burkina Faso	Senegal	Mali
β_1	0.23***	0.33***	0.08	0.21***
β_2	0.46***	0.49***	0.44***	-0.01
θ	0.27***	0.04	0.38***	0.64***
δ	0.004	0.01*	0.01	0.01**
α	-0.73	0.21	0.36	0.29
Adj R^2	0.98	0.98	0.98	0.97

The results from our Chow F-test suggest that the coefficients of the countries that have privatized are different than those in Mali (Table 3). The same can be said for the comparisons between the other countries. We take the average of the coefficient on the lag of the world cotton price in Burkina Faso and Benin and assume that the transmission coefficient in Mali could increase to this level in response to an increase in farmers negotiating power due to privatization. The average of the two coefficients is 0.28, this is an increase of 0.07 from the current coefficient for Mali.

Table 3. Chow F-statistics for Lagged Regression Model in Four West African Countries

	Benin	Burkina Faso	Mali	Senegal
		Chow F-Stat (35,35)		
Benin	-	16.28***	10.73***	7.59***
Burkina Faso	-	-	12.48***	8.92***
Mali	-	-	-	13.17***

***: (Pr>0.01)

We reforecast the farm gate price for the 2007/08 season using the higher coefficient of 0.28 without changing the value of the rest of the coefficients. The forecasted farm gate price increases by 51 percent to 0.53 US$/Kg (Table 4). This implies that the farm gate price for the 2007/08 season would have increased to 0.48 US$/Kg from the observed 0.32 US$/Kg if we assume that the full effect of an increase in farmers negotiating power had been realized

Table 4. Changes in Farm Gate Prices Given an Increase in the Transmission Coefficient of World Cotton Price by 51 Percent.

	Model	Observed
	US$/Kg	
Base	0.35	0.32
Chage in Prices	0.53	0.48
Relative Chage (%)	51	

Exchange rate for 2007: 1 US$= 498 FCFA (Oanda Corporation, 2008)

In summary we find that given the low transmission of world cotton prices back to farm gate prices, an increase in world prices has very little effect in changing farmers' prices. Our results are for a one time increase in world cotton prices. We do not look at the effects beyond a one year period. The effects of such an increase in world cotton prices would fade out in time as other countries increase production. Our study has only evaluated the effects of a removal of US subsidies other factors that could increase world prices are not considered. As illustrated in the 2008 US Farm Bill most of the subsidy programs have been maintained. We could also consider the effects of current commodity market trends as cotton prices have started to rise and evaluate its effects on farm gate prices.

On the other hand increasing the transmission of world prices has a greater effect, doubling to farm gate prices. Our analysis assumes that the effect of an increase in farmers negotiating power is felt rapidly. But increasing negotiating power and for its full effect to be reflected in the transmission coefficient of the world cotton price requires time. Farmers' organizations will have to improve in terms of their management capacity and negotiating abilities. Furthermore, even with better farmers organizations not all the benefits could trickle down to farmers given that these organizations will charge rents to farmers to maintain the bureaucracy.

Section 3. Study Region and Farmer Decision Making

Study Region

Mali, located in the Sahelian zone of West Africa, is one of the major cotton producers in West Central Africa (Figure 1). In 2006/07 Mali's output represented approximately 18 percent of total seed cotton production in the West African region (Baquedano et al, 2008). Total revenues from cotton represented 6 percent of GDP and 30 percent of all exports for that same year, with close to 300,000 farm households producing the crop (Baffes, 2007). Cotton in Mali is rain fed and produced primarily in four regions Koulikoro, Segou, Sikasso and Kayes. In this study we focus on the region of Koulikoro in central Mali. Within Koulikoro, we focused our attention on the cercle[5] of Dioila interviewing 66 farmers in 7 villages between the fall of 2007 and spring of 2008. The major crops produced in this region are cotton, sorghum and maize. Although both sorghum and maize are produced, the former is much more important as both rainfall patterns and soils favor sorghum production over maize in Dioila.

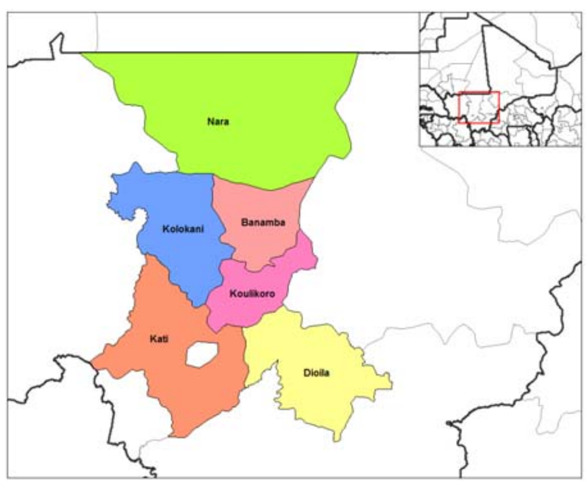


Figure 1. Cercles of the Region of Koloulikoro in Mali, West Africa.

[5] Administratively Mali is organized first by regions, then by cercle and finally villages.

Farmer Decision Making: A Lexicographic Approach

In a representative Malienne farm household, preferences are ordered lexicographically responding to the hierarchal ordering in which farmers satisfy their objectives in this risky environment with substantial price and weather risk (see also Baquedano and Sanders, 2006 and Abdoulaye and Sanders, 2006). In empirical studies in Sub-Saharan Africa (i.e. Baquedano and Sanders, 2006 and Abdoulaye, 2002), farmers state two primary objectives and there is implicitly a third objective: (i) a harvest income goal; (ii) a subsistence consumption objective for staple crops, maize, sorghum and millet in this case; and (iii) income maximization once the above objectives are attained.

Farmers need money at harvest to pay for their purchased inputs and family[6] labor, finance out-migration of family members after the crop season, pay school fees, taxes, health costs, and finance weddings and other ceremonies. The financial obligations pressuring farmers to obtain income at harvest time are so pervasive that most developing countries experience staple price collapses at harvest time. For Malienne cotton farmers, cotton is usually the primary crop upon which farmers rely to meet in part or in total their harvest income goal. More recently though with cotton payments delayed up to 3 months after harvest, farmers have started to rely on cereal grain sales and cattle sales.

The second farmer objective is to put aside sufficient quantities of the main staple to assure subsistence consumption during the year. Many modelers in developing countries have put this as the first constraint. In contrast, a series of empirical studies (Rain, 1999; Abdoulaye, 2002; Baquedano, 2005; Uaiene, 2005) have shown farmers consistently ranking the harvest income goal above the acquiring and storage of subsistence consumption needs until the next harvest. This priority ranking is most obvious in bad rainfall years when most farmers are unable to set aside sufficient subsistence consumption for the year. They rely on the market or

[6] Family labor is compensated by purchasing clothing or giving grain for other family members (besides the household head) to sell.

private/public assistance[7] to obtain sufficient staples later in the year. Nevertheless, they will still first attempt to meet their harvest income goal.

The third objective is to maximize income after these first two objectives have been achieved. This is the standard income maximization objective, but first satisfying the two above objectives makes the farmer risk averse.

Continuity of the objective function is violated, but this is how farmers explain their decision making. This behaviorist approach is based on farmer interviews and how they make decisions, departing from the traditional tradeoff between expected income and risk aversion. While the traditional approach is mathematically elegant it is hard to refute or confirm its ability to predict a meaningful risk aversion coefficient (Yigezu and Sanders, 2008). We would need to be able to determine a decision maker's risk aversion coefficient and then show that with this value we could predict better the choice of activities. In practice this is hard to estimate and a difficult concept for farmers in developing countries to grasp.

Diagrammatically our conceptual approach is illustrated in Figure 1 below. The three components of the African farm-households' utility function (the harvest income requirement, subsistence consumption, and maximization of expected income) can be divided into three non-continuous segments. Up to income level (D) the farmer attempts to achieve his harvest income goal by maximizing his utility function along (JKE). Once obtaining the income level (D), the farmer tries to put aside (DA), the money value of his cereal grain consumption goal by storing sufficient grain, until reaching (A). His utility function in this region is maximized along (EB). Once at (A) he then maximizes expected income along (BC) (see also Yigezu, 2005). With this approach we evaluate the adoption of new technologies under farmers' decision making framework.

[7] Rain (1999) argues that farmers' willingness to sell their grain in bad years despite its scarcity then is enabled by their reliance on complex social ties with family members working in other regions. These ties are a type of social insurance policy in which family members are counted on to provide money and/or food primarily in bad rainfall years.

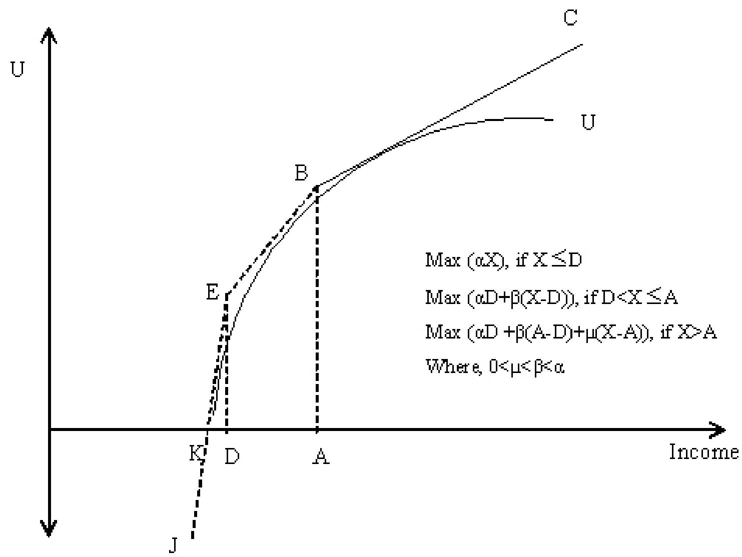


Figure 2. The Conceptual Lexicographic Utility Problem in African Households.
Source: Yigezu, (2005)

4. Empirical Model

The linear programming model that depicts the representative households' decision making framework considers 3 states of nature: bad, normal, and good with respect to rainfall.. To determine the probability of a state of nature we considered both the distribution of prices and rainfall over a ten year period. A bad year is considered to be a year where prices are high and rainfall is 2 standard deviations lower than the mean. A good year is considered to be a year where prices are low and rainfall is 2 standard deviations above the mean. The probabilities of the three states of nature in our model sum to one and are given below in Table 5.

Table 5. Probability of State of Nature

State of Nature	Probability of a State of Nature (%)
Bad	0.30
Normal	0.47
Good	0.23

Source: Authors Calculations from OMA, Mali

There are three traditional technology packages in the model (Table 6). The technological packages (TP) involve six crops: cotton, maize, sorghum, millet, cowpeas, and peanuts. Maize, sorghum, and millet are the main food crops for the household. Cotton, cowpeas and peanuts are the main cash crops. Nevertheless, in the model food crops can also be sold to meet the household income goal. The first TP represents the current production technology used for cotton by farmers in Mali. It is composed of 150 Kg/Ha of the complex fertilizer NPK and 50 Kg/Ha of Urea and includes the use of insecticides and herbicides. Farmers also use fertilizer and herbicides on Maize. The rate of fertilizer used in Maize is of 100 Kg/Ha of complex fertilizer NPK and 50 Kg/Ha of Urea. All other crops use minimum purchased inputs like seed. The yields reported in table 6 for the traditional practices are the averages of a farm household survey completed in 2008.

Table 6. Traditional Technology Packages in the Household Model.

		Bad						Normal						Good					
		Cotton	Maize	Sorghum	Peanut	Cowpea	Millet	Cotton	Maize	Sorghum	Peanut	Cowpea	Millet	Cotton	Maize	Sorghum	Peanut	Cowpea	Millet
	Technology Packages	(Yield, Kg/Ha)																	
	Traditional																		
1	150 Kg/Ha of NPK+50 Kg/Ha of Urea	700						1,200						1,800					
2	100 Kg/Ha+50 Kg/Ha of Urea		890						1,400						2,000				
3	No Fertilizer			700	500	200	700			1,100	800	400	1,000			1,500	1,100	600	1,400

Source: Authors calculations from household survey data (n=66).

Model Representation

The objective function in the model, as stated in Equation [2], maximizes the expected value of adjusted post harvest income, subject to the farmers' objectives of first meeting his harvest income goal that varies by state of nature and then fulfilling his staple consumption objective. The model requires that the income goal (Equation [3]) be met through sales of crops in every state of nature at harvest prices in that particular state. The harvest income goal for each state of nature was estimated from farm-household interviews. The consumption requirement (Equation [4]) can be met from consumption of stored grain or purchases from the market. The consumption requirement of 8,500 kg/annum/household of millet was taken from farm-household interviews and is the same across states of nature. The consumption requirement estimate takes into account the differences in consumption between adults and infants as well as males and females. We chose to take the observed consumption as the base requirement over statistics like the FAO nutritional requirements. This approach was chosen given that if we were to use statistics such as the FAO's, we would be assuming that farmers have perfect information. Instead our approach assumes that at their current level of income given a choice of consuming different consumption bundles farmers would always chose to consume this amount of grain as it is the base for their consumption requirements.

$$MaxE[I] = \sum_S \theta_S I_S \qquad [2]$$

s.t.

$$\sum_c \sum_t SH_{cs} P_{cts} \geq HI_S \qquad [3]$$

$$\sum_c C_{cs} + B_{cs} \leq Cr \qquad [4]$$

Only after these harvest income and subsistence consumption objectives have been met, does the household maximize income. By incorporating the farmers' main objectives under different states of nature, the model responds to the farmers' risky environment in the way farmers explain their own behavior. This approach has been followed previously by Vitale and Sanders (2005) in Mali, Uaiene (2005) in Mozambique, Yigezu (2005) in Ethiopia, and Abdoulaye and Sanders (2006) in Niger.

Equation [5] defines how grain from own production in the household can either be consumed, sold at harvest, or sold seven months after harvest.

$$Q_{cs} = C_{cs} + SH_{cs} + ST_{cs} \qquad [5]$$

Equation [6] is maximized in the objective function and is defined as "adjusted net income" from grain sales 7 months after harvest and income from other activities. Relevant costs for grain storage, production inputs, labor and financing cost have been deducted to obtain the net value. Note that the income maximization in Equation (6) -after assuring the two priority objectives of harvest income and subsistence consumption- also enables him to buy the part of his subsistence requirement not achieved by his own production.

$$I_S = \sum_C SPH_{cs} P_{cts} + \sum_l RT_{ls} Z_l - STC_S - \sum_f \sum_i (ID_{fi} X_i) P_f - \sum_c \sum_t PC_{cts} B_{cts} - \sum_b HLAB_b W_b - CF_s \qquad [6]$$

Equation [7] returns the income definition in Equation [6] back to a more standard income definition by adding back the value of food purchases. Equation [8] defines total expected household income which is the sum of income in Equation [7], plus sales at harvest and the value of own consumption.

$$I_s^* = I_s + \sum_c \sum_t PC_{cts} B_{cts} \qquad [7]$$

$$THI = \sum_s \theta \, (I_s^* + \sum_c \sum_t SH_{cs} P_{cts} + \sum_c \sum_t PC_{cts} C_{cs}) \qquad [8]$$

Equation [9] defines production as the area planted under the technologies available in the model times their respective yields. Equations [10] and [11] define land and labor constraints respectively.

$$Q_{cs} = \sum_i YLD_{cis} X_i \qquad [9]$$

$$\sum_i X_i \leq Ha \qquad [10]$$

$$\sum_i X_i LR_{ib} \leq FLAB_b + HLAB_b \qquad [11]$$

Capital is exogenous in the model, and drives the model results since the new technologies raise the capital requirements. The capital available to the household in the model is the sum of investments incurred by the household in agricultural and non-agricultural activities observed in the 2006/07 season.[8] The total initial capital available to the household in the model for all activities is US$1,988 of which US$ 1,282 was the average expenditure on cotton and maize inputs. The remaining, US$706, was the observed average investment on livestock, veterinary costs of livestock, and entrepreneurial investments made by the household. We allow the model to invest on livestock to increase liquidity to be able to afford the purchase of inputs when new technologies are introduced. The model is solved using linear programming and a detailed description of all the variables is given in table 7 below.

[8] Except for cotton and maize this capital is internally generated by cashing in the farmers' own assets as there is no outside source of capital except informal money lenders at high interest rates. Households own various assets that they can and do cash in on the market including grain stocks, small animals (i.e. chickens), and even larger animals (sheep and goats). These capital levels in the model reflect observed investment levels of farmers from selling off these assets. For cotton and maize the ginning sector provides fertilizer, seed and pesticides on credit and deducts their value from the cotton sold by farmers to them.

Table 7. Subscripts, Variables, and Parameters in the Model.

Item	**Definition**
Subscripts	
B	Labor Period
C	Crop
I	Technology Package
F	Factor Input
L	Livestock
S	State of Nature
T	Sale or Consumption Period
Variables	
B_{cs}	Amount of crop c in state of nature s purchased for consumption
C_{cs}	Amount of own production of crop c in state of nature s destined for consumption
CF_s	Finance cost in state s
$HLAB_b$	Hired labor used in labor period b
I_s	Adjusted post harvest income in state of nature s
SH_{cs}	Amount of crop c in state of nature s sold at harvest
SPH_{cs}	Amount of crop c in state of nature s sold 7 months after harvest
ST_{cs}	Amount of crop c in state s to store for sales 7 months after harvest
STC_s	Storage costs in state of nature s
X_i	Amount of area under technology package i
Z_l	Amount of livestock activity l undertaken in model
Parameters	
θ_s	Probability of a state of nature s
CR	Consumption Goal
$FLAB_b$	Amount of family labor available in labor period b
HA	Amount of hectares of land available
HI_s	Harvest income goal in state of nature s
I_s^*	Post harvest income in state of nature s plus the value of food purchases
ID_{fi}	Demand of input factor $f$by technology package i
LR_{ib}	Labor requirement of technology package $i$in labor period b
P_{cts}	Price of crop $c$in sales period $t$in state of nature s
PC_{cts}	Price of crop $c$in consumption period $t$in state of nature s
P_f	Price of input factor f
RT_{ls}	Return of livestock activity l in state of nature s
W_b	Wage rate in labor period b
YLD_{cis}	Yield of crop $c$under technology package $i$in state of nature s

5. Effects on Household Income of Changes in the World Cotton Price

Having characterized the effects on farm gate prices of an increase in world cotton prices and change in industry structure we now evaluate the effects on household income. To accomplish this we use the empirical model we have developed based on farmers decision making framework. As highlighted previously a 15 percent increase in world cotton prices due to the removal US subsidies only increases farm gate prices by 2.93 percent. Therefore to characterize this scenario we increase the observed farm gate price to 0.33 US$/Kg in our farm household model (Table 8). In contrast an improvement in farmers negotiating power increases farm gate prices by 51 percent to 0.48 US$/Kg. Therefore this is the price level we use to characterize a change in negotiating power (Table 8).

Table 8. Prices for Cotton under Three States of Nature.

State of Nature	Probability of a State of Nature	Base	15 (%) Increase in World Cotton Price	Increase in Transmission of World Cotton Price
	(%)		US$/Kg	
Bad	0.30	0.32	0.33	0.48
Normal	0.47	0.32	0.33	0.48
Good	0.23	0.32	0.33	0.48

Source: Forecast model and CMDT farm gate price data (2007). Exchange rate: 1 US$= 498 FCFA (Oanda Corporation, 2008)

In both scenarios, an increase in the world price for cotton or in its transmission back to the farm gate price, the household only has available their traditional technology packages. The 0.01 US$/Kg increase in farm gate prices from an elimination of cotton subsidy programs in developed countries only increases expected total household income by 2 percent or 45 dollars from farmers current situation (Table 9). When the increase in prices comes from an improvement in farmers negotiating power, as part owners of the gins, household incomes increase 1,223 dollars or 47 percent.

Table 9. Changes in Total Household Income in Three States of Nature and Expected Household Income under Two Policy Scenarios.

State of Nature	Base	Increase in World Price	Increase in Transmission of World Price
		US$	
Bad	872	916	2,717
(% Change)		5	212
Normal	3,215	3,273	4,130
(% Change)		2	28
Good	3,496	3,517	4,536
(% Change)		0.6	30
Expected	2,577	2,622	3,800
(% Change)		2	47

Source: Model Results. Average Annual Exchange rate in 2007: 498 FCFA/US$ (Oanda Corporation, 2008)

Even though farm gate prices increase with an increase in the world cotton price or in its rate of transmission farmers produce less cotton and increase cereal production (Table 10). This result can be better understood if framed within farmers' decision making framework that in our model is represented by the income constraint at harvest, the consumption goal set by the household, and the maximization of income with sales in the price recovery period after harvest. As farm gate cotton prices increase the household requires less area to obtain the same income with cotton to meet its harvest income goal. The area that is recovered from cotton is destined to cereal production, first to increase the households consumption of own grain and then to maximize income in the post harvest period.

Table 10. Model Area Distribution of Cotton and Cereal Grains in Hectares under Farmers current Practices and Two Policy Scenarios.

	Base	Increased World Price	Increased Price Transmission
		Ha	
Cotton	3.63	3.55	3.56
Cereals	6.87	6.96	7.44

Source: Model Results

The results show that consumption from own production increases, as the household decreases its dependence on the market for cereal grain consumption (Table 11). When looking at the highest impact on the farm gate price, which is a higher price transmission, expected consumption of cereal grain from the market is reduced from 24 percent in the base scenario to 11 percent. Additionally we see that in a normal year, with the extra area in cereal production, the household becomes self sufficient in cereals when price transmission is increased (Table 11).

Table 11. Cereal Grain Purchases under Increased Wordl Cotton Prices and Price Transmission

State of Nature	Base	Increased World Price	Increased Price Transmission
	Kg		
Bad	5869	5790	3092
(% of Total Requirement)	69	68	36
Normal	637	513	0
(% of Total Requirement)	7	6	0
Expected	2060	1978	928
(% of Total Requirement)	24	23	11

Source: Model Results

Our results highlight that eliminating subsidies has a very small effect of farmers' incomes. While increasing the negotiating power of farmers has a greater effect. Increasing the negotiating power of farmers almost doubles household income. Attaining reforms in the US and EU agricultural subsidy programs for Mali or other African countries would be hard to accomplish as it requires changing another countries internal policy. Increasing farmers negotiating power by making them owners of the gins while attainable is a long term process. In Burkina Faso and Senegal, where farmers own part of the gins, prices have not increased after reforms and farmers negotiating power while better is still minimal (Baquedano, Abbott, and Sanders 2008). Farmers will have to further develop management and technical skills that they are still lacking in order to increase their negotiating power. Development of such skills is a long term process. Furthermore, at current yields and technology farm households in Mali do not expand production of cotton in response to changes in farm gate price. At current yield levels cereal grains are more profitable than cotton. They also fulfill the households' consumption goal. Thus when making area choices farmers give more importance to cereal grains than expanding cotton.

6. Improving Productivity

We now evaluate the effects on household income of introducing higher fertilizer dosages in cotton, introduction of Bt cotton, and fertilized sorghum supported by marketing strategies. At the end of this section we will then compare the changes in household income from introducing new technologies to increasing world cotton prices and farmers negotiating power.

The causes of the yield stagnation and decline in Mali are attributed to many factors including soil fertility management, lack of varietal development, and adverse rainfall patterns (Fok, 2007). In addition cotton area has been extended into more marginal cotton zones using more extensive cotton practices. There are major efforts in Mali to reverse the decline in yields. There is ongoing research to introduce new technologies based on higher plant densities and increased inorganic fertilizer (IER, 2006 and Fok, 2007). The attitude in Mali towards Bt cotton is also changing, as preliminary results in Burkina Faso where it has been introduced in controlled trials have been positive (Vitale and Park 2007).

The empirical evidence also shows a trend of area reduction for cotton in the last 3 to 4 years in Mali (Vitale and Park, 2007, Fok, 2007 and Baquedano et al., 2008). Farmers are diversifying away from cotton to cereal grains. This diversification is often being supported by cotton fertilizer, as farmers have limited access to other input credit markets in Mali. For this diversification strategy to be profitable to the household it is necessary to provide those farmers wishing to exit cotton with the appropriate technologies. Technologies such as fertilizer and better seed for sorghum and maize that would allow them to increase yields.

New Technologies Introduced in the Model

The first of the three proposed technology packages in the model refer to Cotton (Table 12). Technology package 4 comes from a study carried out by Institute of Rural Economy in Mali or IER (2006). In the IER (2006) study they propose an increase in the rate of NPK complex fertilizer from 150 Kg/Ha to 200 Kg/Ha. Additionally they propose a doubling of plant density per Ha to 80,000 plants/Ha from the current plant density level of 40,000 plants/Ha used by farmers. The yield for a normal year in Table 12 is the average yield found in the IER (2006) study. For a bad and good year we used the same relative variation reported by farmers for their traditional cotton.

Table 12. Traditional and New Technology Packages in the Model.

	Bad						Normal						Good					
	Cotton	Maize	Sorghum	Peanut	Cowpea	Millet	Cotton	Maize	Sorghum	Peanut	Cowpea	Millet	Cotton	Maize	Sorghum	Peanut	Cowpea	Millet
Technology Packages	(Yield, Kg/Ha)																	
Traditional																		
1 150 Kg/Ha of NPK+50 Kg/Ha of Urea	700						1,200						1,800					
2 100 Kg/Ha+50 Kg/Ha of Urea		890						1,400						2,000				
3 No Fertilizer			700	500	200	700			1,100	800	400	1,000			1,500	1,100	600	1,400
New Technologies																		
4 200 Kg/Ha of NPK+50 Kg/Ha of Urea	1,050						1,800						2,500					
5 200 Kg/Ha of NPK+50 Kg/Ha of Urea+BT Cotton Seed	1,200						2,070						3,000					
6 100 Kg/Ha+50 Kg/Ha of Urea			1,120						1,600						2,000			

Source: Traditional Packages 1 to 3: Authors calculations from survey data (n=66); New Technologies: Technology Package 4: estimated from PASE (2006); Technology Package 5: Technology Package 5: estimated from PASE (2006) and Vitale and Parker (2007); and Technology Package 6: Estimated from INTSORMIL (2007).

Technology package 5, introduction of Bt cotton, is the same as technology package 4 in terms of the fertilizer level used. In terms of the plant density it assumes a normal plant density of 40,000 plants/Ha. The advantage of Bt cotton is from the better protection it offers against the bollworm complex in cotton. The gene of the bacteria *Bacillus thurengensis* that controls the bollworm complex is already in the plant. In contrast the traditional method in Mali involves spraying the insecticide Endosulfan on the plant. The efficiency of a sprayed based protection method depends on various factors from the environmental conditions at the moment of treatment to the ability of the person spraying the product. The better delivery of protection that Bt cotton offers has the potential to increase yields and reduce cost by saving up to 4 applications of insecticide in Mali. Furthermore with Bt Cotton you get the additional advantage of eliminating Endosulfan, a dangerous and toxic chemical to humans, from the production chain. Bt cotton is not yet available in Mali, but has been under field experiments in Burkina Faso since 2004. Vitale and Parker, (2007) in an evaluation of these trials found an average increase in yields of close to 15 percent when Bt cotton was used under normal density for cotton. Therefore, we increase the yields of technology package 4 by 15 percent; assume a density of 40,000 plants/Ha; and a reduction of insecticide applications from 5 to 1.

The last technology package, TP 6, is based on the work carried out by IER with the Institute for Sorghum and Millet Research or INTSORMIL in Mali. This technology package included the improved sorghum variety Soumba and moderate dosages of fertilizer. The normal year yield is the average yield obtained by the best producers in the program in the crop year 2007/08. The yields for a bad and good year were calculated using the same level of variation as the traditional sorghum used by farmers today. We make these estimates for different types of crop years since the 2007/08 was the first year farmers used the Soumba sorghum variety and the associated technologies.

Cost of Introducing New Technology Packages

In terms of costs, TP 4 which is composed of higher plant density cotton fertilized at a higher level, requires an increased expenditure in seed of 100 percent from the current cost of 62 US$/Ha and an increase in fertilizer expenditures of 29 percent to 117 US$/Ha (Table 13). For TP 5, Bt cotton, the main driving factor[9] in the adoption of this technology is the cost of the seed. Vitale and Parker (2007) using a programming model found that the profitability of adoption for Bt cotton decreased at seed cots greater than 75 US$/Ha. After this price level adoption by farmers steadily declines. Hence we use their estimate of 75 US$/Ha in our calculations for the cost of Bt Seed given that this is the maximum price at which the technology remains profitable for farmers to adopt. This represents an increase in seed[10] costs'

[9] Determining the cost of Bt cotton seed has been one of the major sticking points of its commercial release in West Africa. Given that the company that controls the technology, Monsanto, has a monopsony position and the potential to charge a high price.

[10] For the crop year 2007/08 farmers in surveys reported a total cost of seed of 2.08 US$/Kg at an annual average exchange rate of 498 FCFA/US$

of 21 percent or 13 US$/Ha. Based on observed insecticide costs in Mali, farmers save approximately 80 percent in their costs of insecticide application by reducing applications from 5 to 1 application for the insect pests not targeted by the Bt gene. Cost of insecticide applications are reduced from 46 to 9 US$/Ha (Table 13).

The cost of the Improved Sorghum Package, TP 6, assumes a reduction in seed cost given the fact that farmers use less seed, as the need for replanting is lowered with improved seed. This assumption is based on the amount of seed used by farmers in their traditional sorghum which was about 9 Kg/Ha and the dose recommended by the program of 4 Kg/Ha. This translates into a savings of 50 percent or 2 US$/Ha (Table 13). Farmers invest 87 US$/Ha on fertilizer in the improved sorghum technology.

Table 13. Average cost per Hectare of the Technology Packages in the Model

		Cotton				Maize			Sorghum		Cowpea	Peanut
		Seed	Fertilizer	Insecticide	Herbicide	Seed	Fertilizer	Herbicide	Seed	Fertilizer	Seed	Seed
		US$/Ha										
	Traditional											
1	150 Kg/Ha of NPK+50 Kg/Ha of Urea	62	91	46	18							
2	100 Kg/Ha+50 Kg/Ha of Urea					4	73	33				
3	No Fertilizer								4		3	14
	New Technologies											
4	200 Kg/Ha of NPK+50 Kg/Ha of Urea	124	117	46	18							
5	200 Kg/Ha of NPK+50 Kg/Ha of Urea+BT Cotton Seed	75	117	9	18							
6	100 Kg/Ha+50 Kg/Ha of Urea								2	87		

Source: Authors calculations from CMDT (2007), Vitale and Park (2007) and Household Surveys. Exchange Rate: 498 FCFA/US$ (Source: Oanda Corporation,2008).

Effects of Improving Productivity

The local government agency IER, in cooperation with the INTSORMIL, has started to introduce improved sorghums that respond to higher dosages of fertilizer. Under their program they have combined the introduction of a higher yielding technology package for sorghum with various marketing concepts. In our study we evaluate only two marketing concepts. The first marketing concept is teaching farmers to produce a cleaner grain, by switching from the traditional methods of threshing on the ground to using a plastic tarp. This has eliminated up to 13 percent of impurities and has enabled farmers to receive a price premium between 15 and 20 percent in Mali (Aminta et al., 2007). In our model when introducing improved sorghum with improved marketing we increase prices reported by farmers at harvest for their traditional sorghum by approximately 17 percent to reflect such a benefit (Table 14).

Table 14. Probability of State of Nature and Prices of Sorghum and Cotton under Traditional and Improved Technologies and Marketing Strategies

State of Nature	Probability of a State of Nature	Traditional Sorghum		Improved Sorghum with Improved Marketing Strategy		Cotton
		Price at Harvest	Price 7 Months Later	Price at Harvest	Price 7 Months Later	Price At Harvest
	(%)	US$/Kg				
Bad	0.30	0.15	0.28	0.18	0.33	0.32
Normal	0.47	0.13	0.25	0.15	0.29	0.32
Good	0.23	0.11	0.22	0.13	0.26	0.32

Source: Probabilities: Authors calculations from OMA-Mali; Sorghum Prices: Farm Household Surveys; Improved Sorghum Prices with Improved Marketing: INTSORMIL (2005); Cotton Prices: CMDT Data (2007). Exchange Rate: 498 FCFA/US$ (Source: Oanda Corporation,2008)

The second marketing strategy that is introduced concurrently, in the IER-INTSORMIL program, is encouraging farmers to store their sorghum at harvest and sell later in the year to take advantage of the price increase. For farmers to store and wait for the price increase they must have access to loans to cover their harvest income necessities. In Mali several of the farmers groups that work in this program have been able to secure inventory credit loans from microcredit institutions to meet their harvest income goals. The loan terms average a maturity of 10 months at an annual interest rate of 15 percent. Inventory credit programs permit farmers to sell their grain six to ten months after the harvest and then repay the storage agency, such as the farmers' organization or micro credit institution, for the costs of storage and interest. The program provides credit at harvest time based upon harvest time value of the grain. Farmers then repay the loan plus interest and storage costs when the price increases to a point that is profitable for them to sell. This allows farmers to capture the price variation for their staple crop between harvest and later in the year. This potential, according to farmers' price estimates for their traditional sorghum, could be as much as double the harvest price as prices increase during the hungry season 7 months after harvest (Table 11). In the model we further increase prices 7 months later by the premium for selling cleaner sorghum. Additionally, in the model, we introduce inventory credit storage, as an alternative to their own storage. In our field work we found that even though farmers groups have up to 10 months to repay their loans on average loan reimbursement occurred no later than 7 months after harvest. Therefore, in our model this is the repayment period that we use. We incorporate as well the relevant storage and interest cost calculated from survey work of this program and highlighted in this paragraph.

When we give farmers the alternative to diversify away from cotton into the improved sorghum and marketing program we notice two particular shifts in crop area. The first shift happens in cotton, area under cotton is reduced by a little over 4 percent (Table 15). The second major shift is that the household no longer produces maize. The fertilized sorghum technology package has higher yields than the traditional maize[11] production package. Additionally sorghum under the marketing project commands a higher price than maize. The combined effect of yield and price causes maize to drop out.

[11] The area where our data was collected from is located in North Central Mali. In this region soils are light and there is less rainfall, which favors Sorghum over Maize production. In the southern parts of Mali, Maize production, is more common and substantially out yields sorghum.

Table 15. Crop Area Distribution under Improved Sorghum and Marketing

	Base	Improved Sorghum with Marketing Strategy
	Ha	
Cotton	3.63	3.48
(%) of Total Area	33	32
Maize	1.03	0.00
(%) of Total Area	9.4	0
Sorghum	5.83	7.02
(%) of Total Area	53.0	63.8
Cowpea	0.50	0.50
(%) of Total Area	4.5	4.5
Total Area Planted	11.00	11.00

Source: Model Results

Participation in the improved sorghum and marketing program increases expected household incomes by 54 percent or US$ 1387 dollars (Table 16). The increase in expected household income is most important in bad years where it is 254 percent higher than the base situation. In the model in a bad year the household obtains a double benefit. First of all, as it produces more it relies less on the market to purchase cereal grains for consumption especially mid-year when prices are at their highest. Second, the relative higher value of consumption is higher thus increasing household welfare.

Table 16. Expected Household Income under Traditional Practices and Improved Sorghum and Marketing

State of Nature	Base	Improved Sorghum with Marketing Strategy
	US$	
Bad	872	3,083
(% Change)		254
Normal	3,215	4,265
(% Change)		33
Good	3,496	4,498
(% Change)		29
Expected	2,577	3,964
(% Change)		54

Source: Model Results. Average Annual Exchange Rate in 2007: 498 FCFA/US$ (Source: Oanda Corporation,2008)

When introducing the improved cotton activity and Bt cotton in addition to the improved sorghum program several shifts in crop area occur (Table 17). When looking just at improved cotton, using the IER technology package, we see that cotton area is further reduced. This result is intuitive, given that expected cotton yields increase 46 percent; farmers are able to produce more cotton using less area. The household prefers to increase its participation in the improved sorghum program where it can obtain not only higher yields for sorghum but also a higher price. This situation reverses itself when Bt Cotton is introduced (Table 17). The expected yield gains of Bt cotton over farmers traditional cotton technology outweigh the benefits of the improved sorghum program. But farmers only moderately reduce the area under the improved sorghum program.

Table 17. Distribution of Crop Area under the Households Traditional Practices and Three New Technology Packages.

	Base	Improved Sorghum with Marketing Strategy	Improved Sorghum with Maketing Strategy and Improved Cotton	BT Cotton and Improved Sorghum with Marketing Strategy
			Ha	
Cotton	3.63	3.48	3.34	5.28
(%) of Total Area	33	32	30.3	50
Maize	1.03	0.00	0	0
(%) of Total Area	9.4	0	0	0
Sorghum	5.83	7.02	7.17	5.31
(%) of Total Area	53.0	63.8	65.2	50
Cowpea	0.50	0.5	0.49	0
(%) of Total Area	4.5	4.5	4.5	0
Total Area Planted	11.00	11.00	11.00	10.59

Source: Model Results

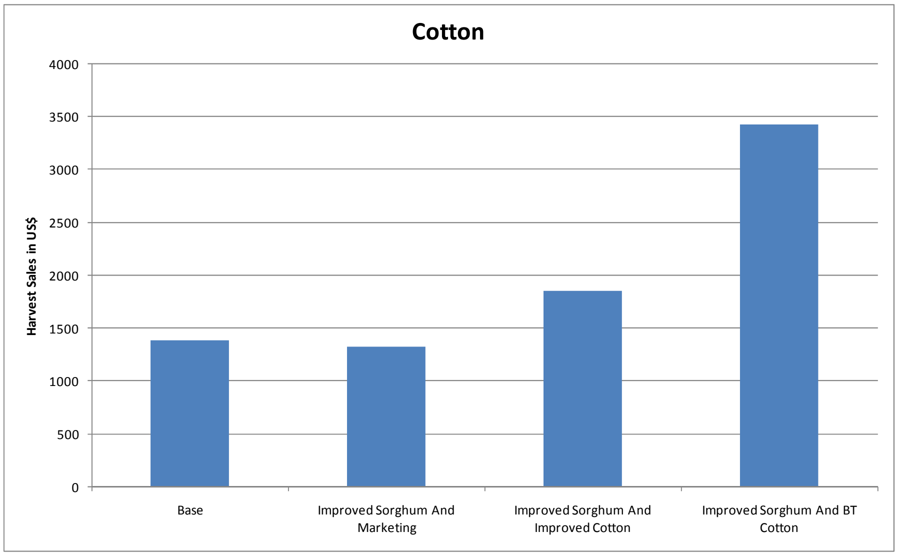
In terms of changes in expected total household income these continue to increase as farmers go from improved sorghum to introducing Bt Cotton (Table 18). When complementing the improved sorghum and marketing program with improved cotton this increases household income by 90 percent over the traditional practices. When Bt Cotton is introduced with improved sorghum and marketing, expected total household income increases by 114 percent compared to the traditional practices (Table 18).

Table 18. Expected Household Income under the Households Traditional Practices and Three New Technology Packages.

State of Nature	Base	Improved Sorghum with Marketing Strategy	Improved Sorghum with Marketing Strategy And Improved Cotton	Improved Sorghum with Marketing Strategy And BT Cotton
			US$	
Bad	872	3,083	4,555	4,091
(% Change)		254	423	369
Normal	3,215	4,265	4,942	5,756
(% Change)		33	54	79
Good	3,496	4,498	5,263	6,839
(% Change)		29	51	96
Expected	2,577	3,964	4,900	5,506
(% Change)		54	90	114

Source: Model Results. Average Annual Exchange Rate in 2007: 498 FCFA/US$ (Source: Oanda Corporation,2008)

To better understand where the advantages with respect to household income come from in the model we present the changes in gross revenue sales of cotton at harvest and gross sales of sorghum 7 months after harvest in Figure 3 below. As would be expected we see that overall better technology increases cotton gross revenue sales at harvest and thus its contribution to household income. When introducing improved sorghum technology that is accompanied by better marketing, the increase in gross revenue sales is greater than that of cotton except when compared to Bt cotton (Figure 3). Under Bt cotton practically all of the increase in expected household income can be attributed to the introduction of this technology (Figure 3).



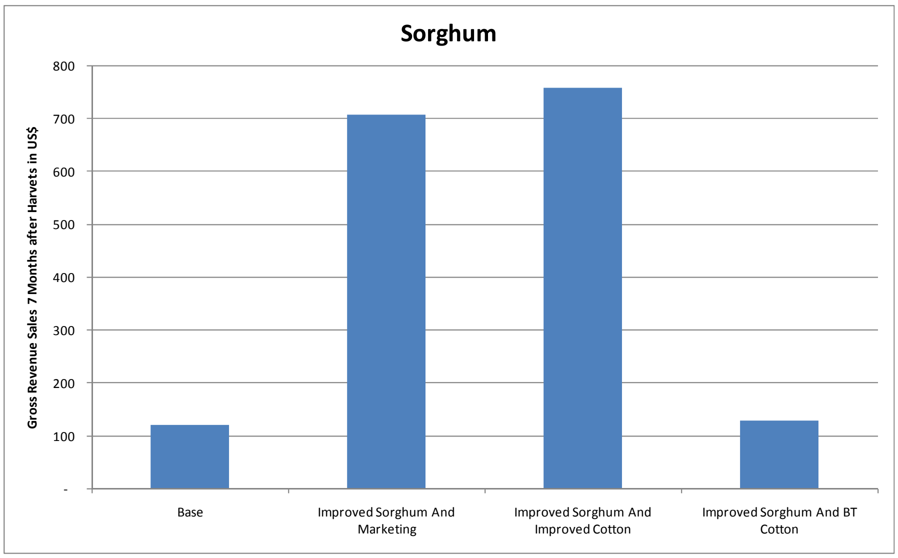


Figure 3. Gross Revenue Harvest Sales for Cotton and Gross Sales 7 Months after Harvest for Sorghum. Source: Model Results. Average Annual Exchange Rate in 2007: 498 FCFA/US$ (Source: Oanda Corporation,2008)Average Annual Exchange Rate in 2007: 498 FCFA/ US$ (Oanda Corporation, 2008)

Increasing World Cotton Prices and Their Transmission versus Productivity Change

When comparing the income effects of increasing world cotton prices or their rate of transmission with increasing productivity, we see that the latter has a greater effect (Table 19). Improved sorghum increases household incomes by 52 percent more than increasing world cotton prices due to removal of subsidies. Even though the income advantage of increasing productivity over increasing the transmission of world cotton prices (by increasing farmers negotiating power) is small 7 percent, obtaining the latter could be difficult. Cotton farmers are well accustomed to managing production activities at the farm level and can respond quickly to introduction of new technology. The benefits that farmers could obtain from being part owners of the gins depend on gains in bargaining power. As discussed before farmers also need to develop the necessary managing skills to maximize their gains from being owners of the gins. This can take relatively longer then introducing new production technologies.

Table 19. Expected Household Income under Two Policy Scenarios, Technology Introduction and Traditional Practices.

State of Nature	Base	Improved Sorghum And Marketing	Increase in World Price	Increase in Transmission of World Price
			US$	
Bad	872	3,083	916	2,717
(% Change)		254	5	212
Normal	3,215	4,265	3,273	4,130
(% Change)		33	1.8	28
Good	3,496	4,498	3,517	4,536
(% Change)		29	0.6	30
Expected	2,577	3,964	2,622	3,800
(% Change)		54	2	47

Source: Model Results. Exchange Rate: 498 FCFA/US$ (Source: Oanda Corporation, 2008)

We find that the effects of productivity changes are substantially higher than increasing farm gate prices. If anything higher prices can be enhanced by productivity gains. Few expect big policy modifications to the subsidy programs of developed countries (Anderson and Valenzuela, 2006, Tschirley et al., 2007). This was evidenced in the current US Farm bill that was passed by congress in 2008. Hence increasing productivity in Mali, of which the national policy makers have more control of, appears more feasible and has the potential to have greater effects than a modification in US subsidies or further structural adjustment in the cotton markets.

7. Conclusions and Policy Implications

In this study we have focused on the effects on farm gate prices and household income of three strategies: eliminating US subsidies, reforming the cotton sector and increasing productivity. The removal of US subsidies has a minimal effect on farm gate prices while reforming the industry structure doubles farmers' prices. Our results have also highlighted that changes in productivity have a greater effect on household incomes than the elimination of US cotton subsidies. Improving the productivity of cotton and other crops, at a minimum, more than doubles household incomes. In our analysis we considered Bt cotton within the production technologies available to the household. We showed its advantages with regards to costs and income to the household. But it is also important to highlight that Bt cotton also offers the added advantage of eliminating toxic chemicals from the cotton production chain as this effect is not captured in our modeling.

When analyzing the effects on household incomes of reforming the cotton sector we have concentrated on one aspect. The reforms call for privatization of the cotton sector and as part of that roadmap it is foreseen that part of the gins will be sold to farmers. This would enable farmers to increase their negotiating power and it would translate into higher rates of transmission of world price back to farmers. The effects of greater negotiating power on household income have almost the same effect as increasing productivity. But changing the level of negotiating power of farmers might take more time than introducing better production technologies to which farmers responds more quickly. We still need to explore other alternatives of evaluating the reform process and see how it would directly affect farm gate prices and household incomes.

We have also shown that promoting the improvement of other crops, such as sorghum, can have positive and significant effects on farm-household income. Diversification of production and marketing is becoming increasingly important as farmers respond to the price cost squeeze in cotton. If successful alternative crop markets are fostered, including the further development of credit markets, the new crops would no longer depend on the cotton fertilizer for their development.

8. References

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