ECONOMIC CONSEQUENCES OF DIFFERENT INSTITUTIONAL STRUCTURES FOR THE COTTON SECTOR IN WEST AND CENTRAL AFRICA: EVIDENCE FROM BURKINA FASO

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Abstract: In West and Central African countries parastatal vertical coordination is used to control both the input and output markets. The decline of cotton yields and subsequent decline of the parastatals' performance in the late 1990s called for reforms. This thesis assesses the potential economic effects of different institutional structures for the parastatals in West and Central Africa, using the characteristics of the cotton sector in Burkina Faso. The thesis is based in the concept of economic surplus. A structural system is developed to measure the potential economic outcomes of three market alternatives to parastatal vertical coordination. Results demonstrate that when a parastatal is allowed to exercise market power, it extracts rents from the farmers maximizing the parastatal's economic surplus. The primary beneficiaries of the privatization of the cotton sector in West and Central African countries are the farmers, as a result of the higher price received in the output market. The parastatal extracts more from the output market than from the input market. With partial privatization farmers are better off when they receive the competitive cotton price, even when the parastatal exercises monopoly control of the input market, extracting rents from the farmers, than they are when the parastatal exercises monopsony in the output market (cotton buying) and farmers procure inputs in the competitive market.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

Cotton is one of the most important cash crops in sub-Saharan Africa. In many of the countries of the region growing cotton is the primary source of employment in the rural areas accounting for a substantial share of the cash income (Elbehri and Macdonald, 2004). Additionally, it is the prime export commodity in the region, accounting for 15% of world cotton exports, ranking third behind the United States and Uzbekistan (Baffes, 2001). The "C-4" (Cotton-4) countries - Benin, Burkina Faso, Chad, and Mali - alone account for 8% of world cotton exports. However, they have no significant influence on world cotton trade (Alston, Sumner, and Brunke, 2007).

The cotton sector in West and Central African countries is dominated by smallholder farmers that normally grow cotton for cash income along with food crops (cereals and vegetables) that satisfy family consumption needs. The cotton sector in this region has been growing for the past four decades and significantly contributes to the economic growth of the sub-Saharan Africa region (Elbehri and Macdonald, 2004; Falck-Zepeda, Horna, Smale, 2007).

The West and Central African cotton market is a prime example of an imperfectly competitive market which is dominated by state owned cotton companies (parastatals). The cotton sector in this region is vertical coordinated with few differences among countries. A single parastatal company in each country retains legal monopoly on the input market providing the farmers with many of the necessary non-labor inputs (seed, pesticide, urea, extension services, and others) and also legal monopsony on the output market, buying all the cotton from the farmers. This parastatal vertical coordination system (Figure 1) has allowed the parastatals to set the input and output prices, extracting significant rents from the farmers (World Bank, 2000).

Until recently, the pricing system used in this region was similar in nearly all of the countries; the prices were the same across the growing area (panterritorial), fixed throughout the growing season (panseasonal), and were set and publicly announced by the parastatal before the beginning of the planting season (Badiane et al. 2002, Elbehri and Macdonald 2004, Baffes, Tschirley and Gerley, 2009). This pricing system guaranteed an anticipated and equal price among the farmers; however, it penalized the most efficient and productive ones. Moreover, extracting rents from the farmers restrained the potential to reinvest in research, cost minimization technology constraining the overall growth of the cotton sector. The system described above allowed for a rapid growth of cotton production and exports in the mid-1990s. Despite that, later in the 1990s declining of performance of the parastatals, declining cotton yields and prices, and high volatility in the sector led to calls for reforms (Baffes, 2007).

Recent evidence shows that this vertical coordination system (Figure 1) has reached its performance peak and it is less likely to survive in this current scenario of increasing competition and globalization (World Bank, 2000; Vitale et al., 2009). The proposed reforms aimed in order to break down the existing vertical coordination and allow for privatization of the sector in order to increase competitiveness and overall performance of the sector (Banghdadli, Cheikhrouhou and Raballand, 2007). While this vertical coordination structure continues to prevail in many of the countries, where the government still controls the cotton trade, some have undertaken reforms that partially or completely liberalized the sector, allowing for the entrance of a limited number of ginning companies. However, monopsony power in the output market continues to exist (Falck-Zepeda, Horna, Smale, 2007; Vitale et al., 2009).

Objectives:

This thesis assesses the potential economic consequences of allowing different market structures in the cotton sector in West and Central Africa by developing an economic model to compare the potential economic outcomes of departing from the current parastatal vertical coordination into more competitive alternatives. More specifically, the objective is to determine the prospective gains in the producer's surplus of migrating from the current parastatal vertical coordination to more competitive market structures, using the features of the cotton sector system in Burkina Faso.

The working hypothesis for this paper is that under this current institutional structure, monopoly power in the seed industry is undermined by monopsony power in the buying of cotton: more rents are extracted from the output rather than input market. However, if the cotton industry is privatized a different stream of rents would be extracted.

The rest of this thesis is organized as follows. In chapter II a brief literature review of the historical background of cotton and the outcomes of reforms in cotton sector in West and Central Africa is presented. In chapter III the theoretical framework is presented. This is followed by the model specification in chapter IV; in chapter V the procedures and data are presented; and in chapter VI the results are presented and discussed, and compared; the last chapter is reserved for final comments and conclusions.

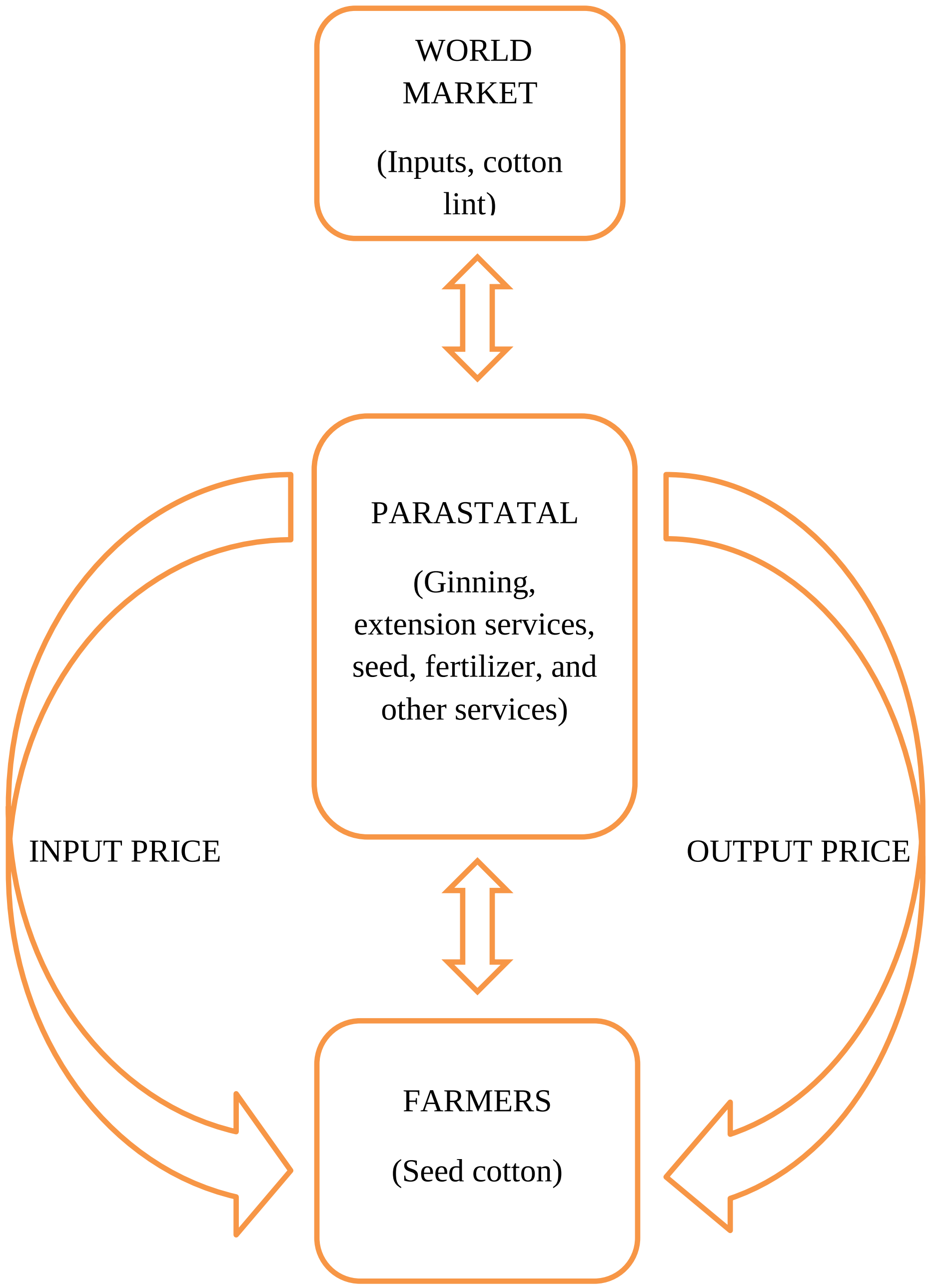

Figure 1. Parastatal Vertical coordination system in West and Central Africa.

CHAPTER II

REVIEW OF LITERATURE

2.1 Historical background: Cotton in West and Central Africa

Cotton was introduced in West and Central African French colonies during the colonial era to supply the French textile industry with seed cotton (World Bank, 2000). The cotton production and marketing was secured by a French state owned company the "Compagnie Française pour le Developpemnent des Fibres Textiles" - CFDT. Following independence in 1960, CFDT remained as a small shareholder, and a number of national cotton companies (parastatals) were created in the different countries of the region with the local governments retaining the majority of the shares (Gerley and Poulton, 2009). From that time, the cotton sector in this region has been dominated by a parastatal company in each country that exerts vertical control over the sector from farm to ginning. The parastatals, until the pre-reforms era, retained legal monopoly power in input supply (seed, pesticide, urea, extension service, and other), marketing, cotton ginning, and monopsony power in cotton buying extracting considerable rents from the farmers (Baffes, 2007; Vitale et al., 2009; World Bank, 2000**).**

The parastatal vertical coordination system (Figure 1) increased the cotton farming area, and significantly contributed to the economic growth of the region (Baffes, 2007). Figure 2 shows that from 1961 to 2000 the cotton yields in West and Central Africa increased by four fold, and production by more than 20 fold (Elbehri and Macdonald 2004).

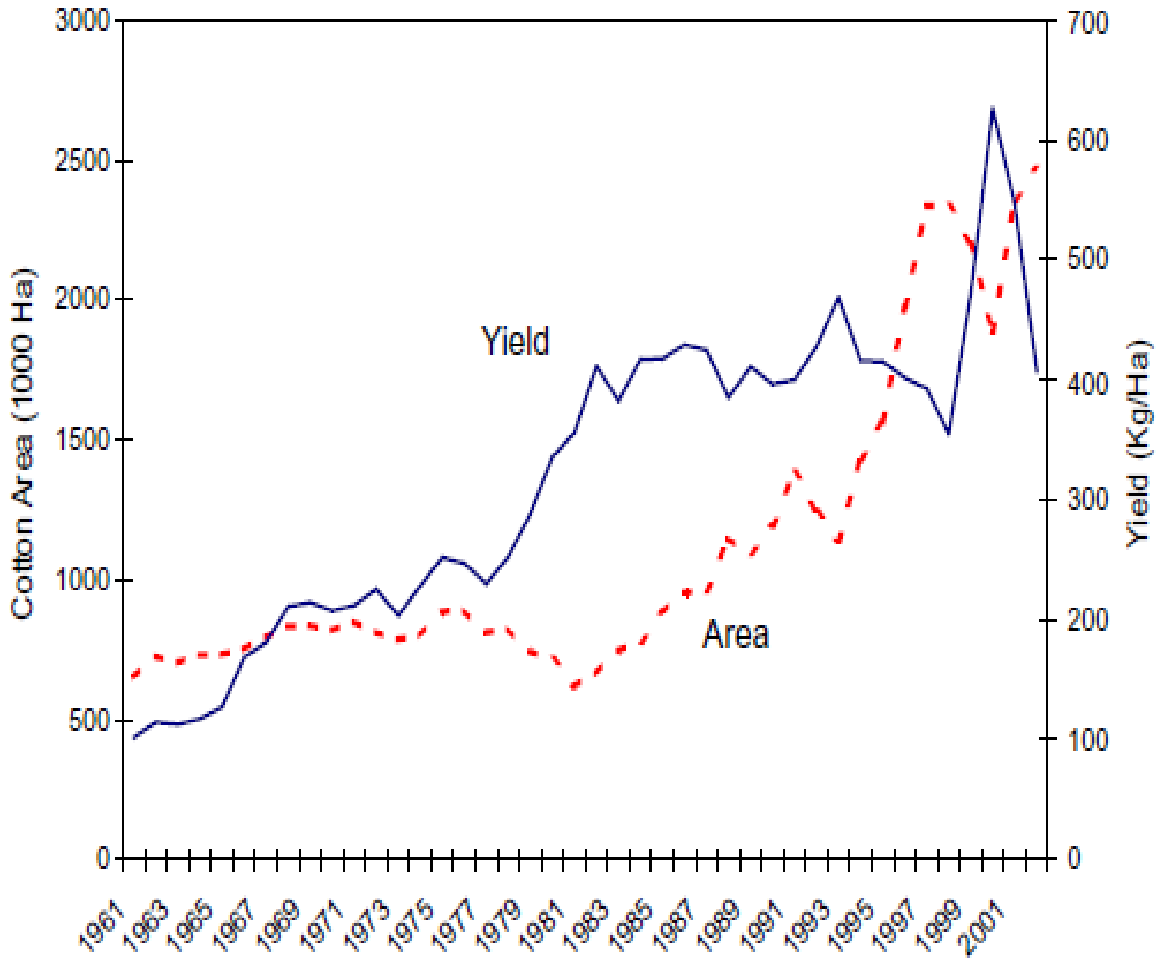

Figure 2. Cotton area and yield trends in West and Central Africa **(***Source:* Elbehri and Macdonald, 2004).

However, recent evidence shows that this system has reached its performance peak. Beyond that, the declining performance of the cotton companies, and declining world cotton prices and yields, along with financial crises in most of the cotton companies, led to calls for reforms attempting to improve competiveness and improve the share of the cotton world price captured by the farmers (World Bank, 2000; Vitale et al., 2009).

There are four important and distinguished phases of incentives to the cotton farmers in the region. In the first phase, ranging from 1970-1984, cotton farmers received roughly one third of the world cotton price; in the second phase, from 1985-1993, which was distinguished by poor world cotton prices, high inflation, financial crises of the majority of the cotton companies, and heavy financial aid to the cotton companies to face the crises the farmers earned up to 55 percent of the world price. The third phase, from 1994-1997, was marked by a decline of world commodity prices as a result of a financial crisis in East Asia with the farmers receiving about 42 percent of the world price. During the last phase from 1998 until the early 2000s world cotton prices declined, majority of the cotton companies experienced financial crises, and with the farmers capturing a considerably greater portion of the world price (around 59 percent) than historically (Baffes, 2007). Historically, cotton farmers in West and Central African countries have received poor prices even when the cotton world prices were at their highest levels. Reforms of the cotton sector to increase competition and boost the share of the world price received by the local farmers have been proposed. These reforms aimed to limit government intervention in price setting and subsidies in the cotton market. These reforms, accompanied by improvements in the efficiency of the cotton ginners, were expected to increase income to cotton farmers and boost cotton production, and the world export share of the region. However, in some countries – Burkina Faso and Mali – the vertical coordination still prevails owing to the benefits it brought to the sector in the countries (Badiane et al., 2002; Baffes, 2007; Gerley and Poulton, 2009).

2.2 Moving towards a competitive cotton sector

Moving to a more competitive cotton sector is not an easy task; and it is expected to take several years. To achieve a successful transition, the reform plan has to take into account the particularities and institutional environment in each individual country (Badiane et al., 2002). Privatization of the cotton sector in West and Central Africa has been recommended to improve management of companies, reduce production costs, and limit government intervention. However, privatization has been restrained in most of the countries. Experience from the countries that have undertaken these reforms, partially or totally privatizing the cotton sector, show that privatization has had positive results (Gergely and Poulton, 2009).

Privatization of the cotton sector and increased investment allowed for countries in Africa to revitalize cotton production and the farmers to receive a higher share of the world price (Poulton et al., 2004). However, the higher price shares received were rapidly lost due to lack of an efficient input market supply, infrastructures, and other services required in the cotton production (Gourex and Macrea, 2003, Vitale et al 2009, Poulton et al., 2004).

The primary beneficiaries of the privatization and subsequent elimination of market power and other pricing distortions in the cotton sector are the farmers, receiving higher world cotton price shares (World Bank, 2000). Poulton et al. (2004) argue that the higher prices incentives in the competitive market make growing cotton more attractive, and bringing in more productive and efficient farmers. Furthermore, studies (Gourex and Macrea 2003; and Poulton et al., 2004) show that privatization of the cotton sector in sub Saharan Africa increased the prices received by the farmers, however results varied when a small number of cotton companies dominated the market. In Tanzania, an example of a competitive cotton industry in Southern African the share of the price received by the farmers increased rapidly from 49% to 70%, five years following the reforms on the sector. While in Zambia and Zimbabwe, countries characterized by a concentrated cotton sector dominated by no more than three firms, the gains on the farmers share of the world rapidly decreased after the reform period.

Most West and Central African countries maintained the parastatal vertical coordination and have had better farmers price shares compared to the Southern East African countries that engaged in reforms of the cotton sector (Kaminski, 2011). This performance difference is explained by the increased bargaining power of the farmers in the late 1990s. For instance, by 2004 in Burkina Faso part of the farmers owned 30% of the cotton company. The cotton prices are now negotiated before the beginning of the planting season with the participation of the farmers (Bourdet 2004; Kaminski, 2011). The increased bargaining power of the farmers allowed them to quickly raise the share of the world price captured by the farmers (Figure 3). The farmer's price share rapidly increased from one third in the mid 1980's to about 58% in the late 1990s; reaching to a high of 73% during the period of 2000-2005 (Tschirley, Poulton, and Labaste, 2009).

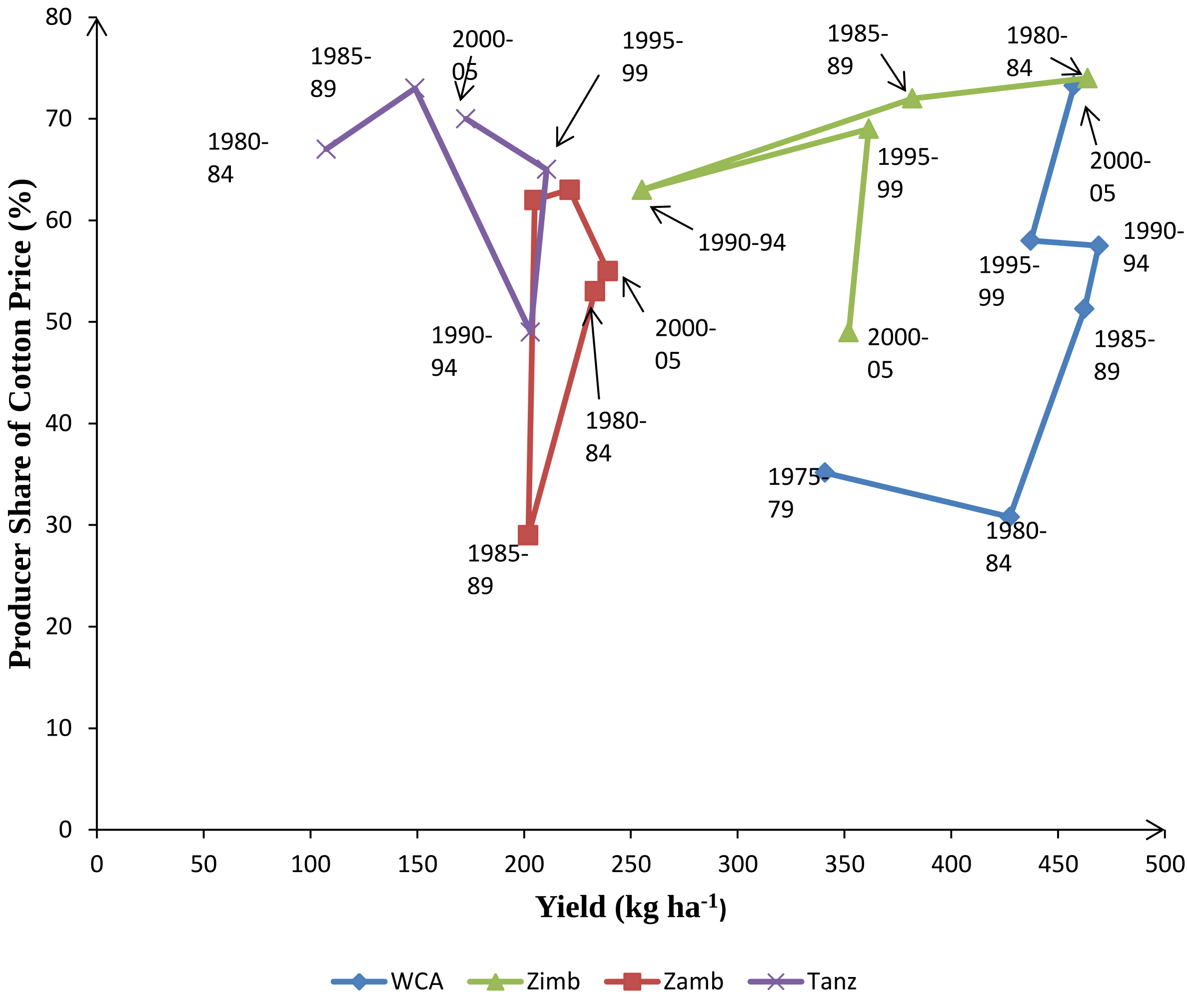

Figure 3. Producers world price share in West and Central Africa and South eastern Countries (*Source: Tschirley, Poulton, and Labaste, 2009*).

For example, in Tanzania the share of the price captured by the farmers after the late 1990's reforms rapidly increased to 70% by 2000-05. This increase in the price share received by the farmers was also accompanied by an increase in yields to about 211 kg/ha by 1999 (Figure 3). In Zimbabwe, however, the share of the prices received by the farmers rapidly decreased after the reforms took place in the early 1990s accompanied by a decrease in the yields as well; by 2000-05 the share captured by the farmers in Zimbabwe had decreased to 49% (Figure 3).

CHAPTER III

THEORETICAL FRAMEWORK

The purpose of this thesis is to assess the potential economic consequences of three alternative structures to the parastatal vertical coordination in cotton sector in West and Central Africa. This study is based on the concept of economic surplus (total welfare) as described by Alston et al. (1995), where the producer's surplus is defined as the total revenue minus total costs of production of the good.

Reforms to privatize the cotton sector in West and Central African in order to improve the competiveness of the sector and allow for the farmers to benefit from increased share of the world cotton price have been proposed (Gergely and Poulton, 2009; Badiane et al., 2002). This study analyzes three alternatives to the current parastatal vertical coordination system. The first alternative is to allow for the parastatal to keep monopoly control of the input market and let the farmers sell their production in the world market. A second alternative is to allow for the producers to procure the inputs in a competitive market and let the parastatal act as a monopsonist as it buys cotton, and the third alternative is to completely privatize the cotton sector and let the farmers sell their production and procure the inputs in the competitive market.

3.1 Extracting rent from the output

The quantity produced (*S*) in the competitive market is derived using the producers' marginal cost, and to compare the world market quantity to the quantity produced in the local market a ginning efficiency ratio of 40% is used.

In Figure 4, *S* denotes the original cotton supply under competitive conditions, *a* is the reservation price for cotton which is the minimum price required to entice farmers to engage in cotton production and it is a function of the prices of other food crops (cereals and vegetables); p_w is the cotton lint world price (under competitive conditions); p_p is the demand price the parastatal pays farmers for the cotton; Q_l is the aggregated cotton (lint equivalent) quantity supplied by the local market under monopsony power ; and Q_w is the cotton lint equilibrium quantity under competitive conditions.

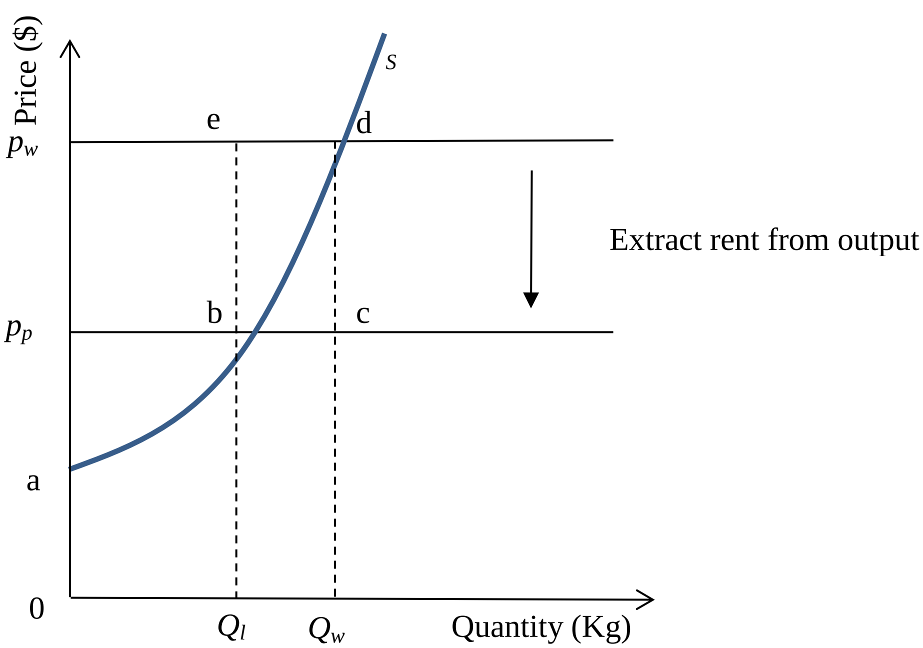

Figure 4. Rent extraction on the output market under monopsony.

If farmers received the cotton competitive market price (p_w), the producer's surplus would be equal to the area $adp_{w;}$ however, the parastatal company exercises monopsony power in the output market and sets the price (p_p) below the competitive market price extracting rent from the farmers. This results in a change in the producer's surplus equal to the difference between the areas adp_w and abp_p.

The area p_webp_p is the rent the parastatal extracts by enforcing their pricing power on the output market, and the area *bed* is the deadweight loss generated as a result of the parastatal monopsony on the cotton buying.

Using the illustrative example of a single input, in this case urea with 46% of nitrogen, the parastatals could induce cotton production by subsidizing the price of the urea. The subsidy lowers the urea price paid by farmers from r_w (world urea price) to r_p (urea price the parastatal charges the farmers), boosting the quantity used from Q_{wi} to Z_i which is the profit maximizing level of urea for the farmers under subsidy (Figure 5).

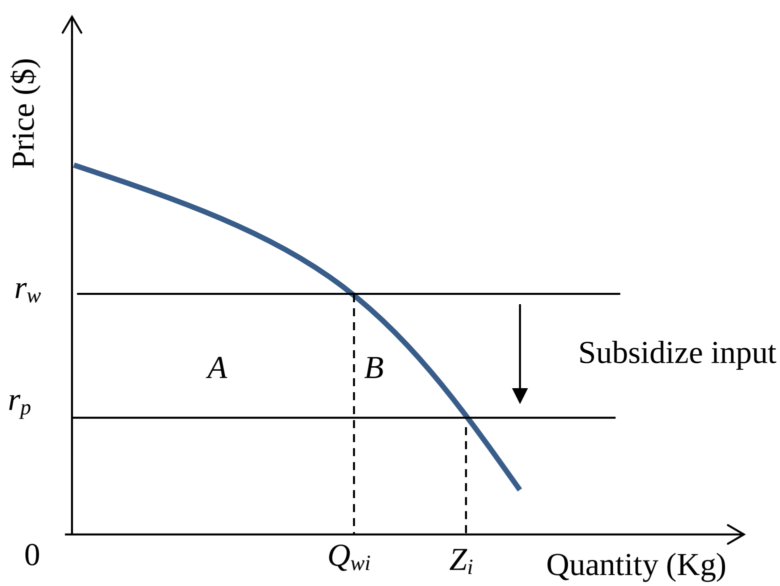

Figure 5. Parastatal subsidy on the input market.

The increased quantity of urea used will have a positive effect on the cotton output by increasing the quantity produced from Q_l to Q'_l, and shifting the cotton supply to the right from *S* to *S'*, assuming the cotton lint price in the local market is maintained at the same level (p_p) below the world price (p_w) (Figure 6). This supply shift will increase the rent extracted by the parastatal by adding the area *ebgf* to the area $p_p bep_w$ (rent extracted under the original cotton supply). The change in the producer's surplus is given by the difference between the areas $p_p ga$ and $p_p ba$ (Figure 6).

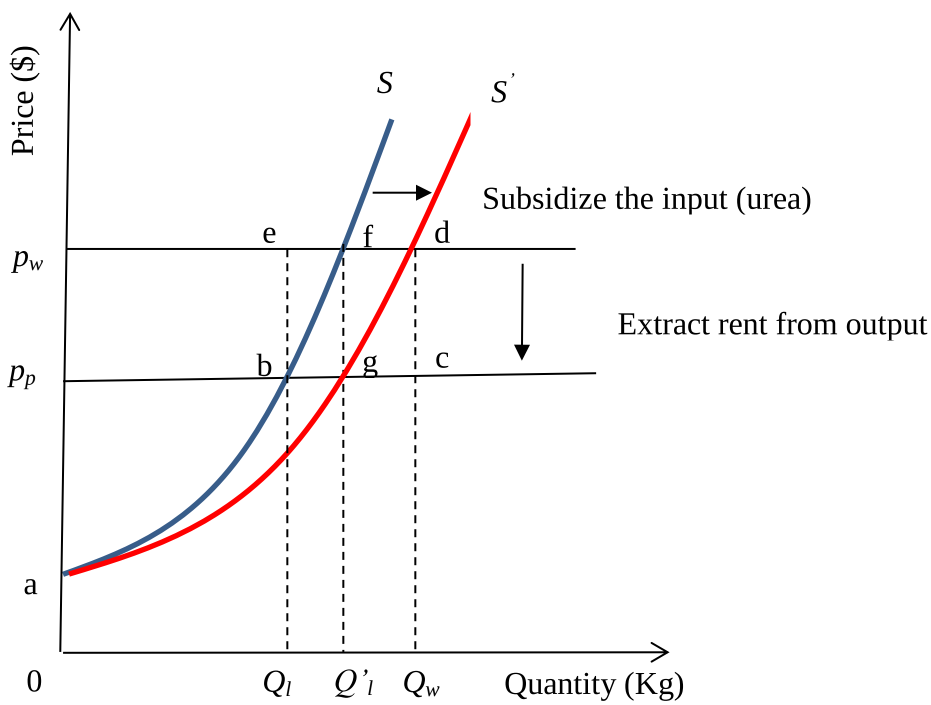

Figure 6. Supply shift due to subsidy on the input (urea) market.

The parastatal subsidy in urea is equal to the sum of the areas *A* and *B* (Figure 5). The parastatal companies will only subsidize urea if the expenditure with the subsidy is less than the rents extracted in the output market, $A+B < p_w fg\, p_p$.

3.2 Extracting rent from the input

If the parastatal extracts rent from the input market by selling urea at a price (r'_w) higher than the world market price (r_w), the quantity of urea used will decrease from Q_{wi} to Q'_{wi} (Figure 7).

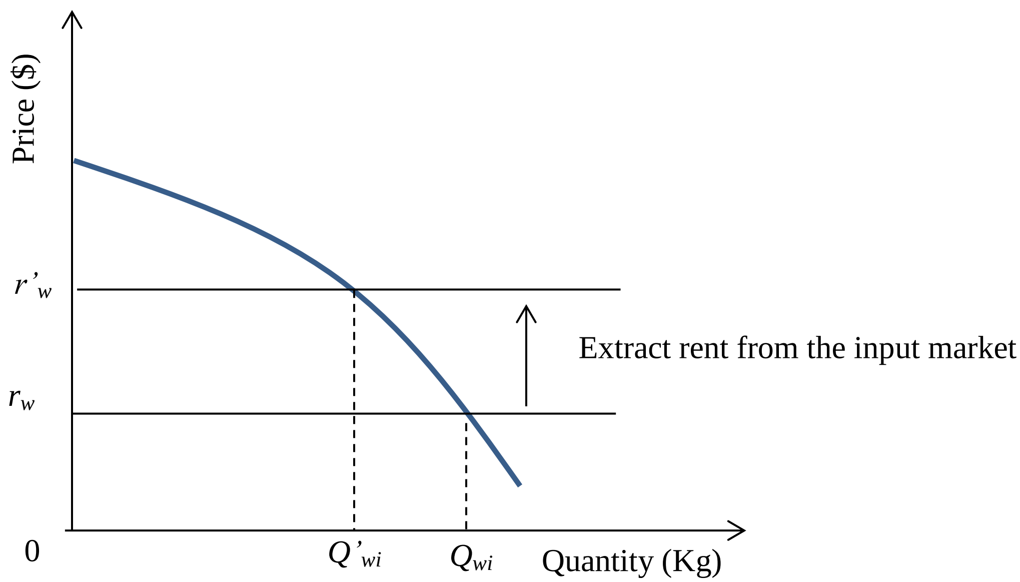

Figure 7. Extract rent from the input market.

This decrease in the quantity of urea used will negatively impact the output by decreasing the quantity of cotton produced from Q_w to Q''_c, shifting the cotton supply curve to the left from S to S''. The rent extracted by the parastatal is equal to the area $p_p jip_w$, and the change in the producer surplus is given by the difference of the areas $p_p ca$ and $p_p ja$ (Figure 8).

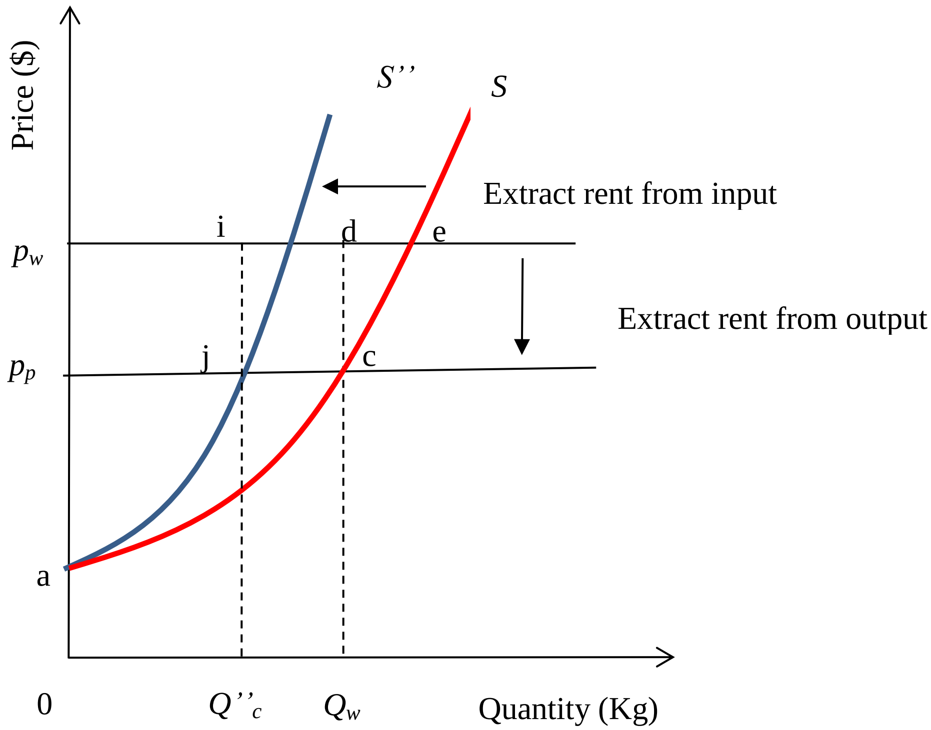

Figure 8. Supply shift due to rent extraction on the input.

3.3 <u>No rent extraction by the parastatal</u>

With the current parastatal vertical coordination the surplus distribution in the cotton sector is unequal. If a more competitive market is permitted by privatizing the cotton sector and allowing more companies to enter the market, a different stream of rents would be extracted and the farmers would benefit from the higher output prices and lower input prices on the competitive market. In a competitive market, the welfare is greater than with the parastatal system and the farmers capture the surplus generated so the parastatal profit is zero (Vitale et al., 2009).

CHAPTER IV

THE STRUCTURAL MODEL

National cotton companies maximize profit by purchasing cotton from smallholder farmers, and contractual agreements require farmers to sell all of their cotton to the parastatal at pre-planting announced prices. With vertical control over the cotton sector, the parastatal sets both input and output prices, and through extension services is able to act as the primary technology provider (Badiane et al. 2002, Elbehri and Macdonald 2004, Baffes, Tschirley and Gerley, 2009). Those features are established in the theoretical model through decision variables for input and output prices, and their influence on aggregate supply. Farmers are price takers, but cotton competes with food crops for resources (Tschirley and Gerley, 2009). Opportunity cost of land, labor, and capital establish a minimum price for cotton. Aggregate cotton supply is obtained by summing over the farming population, which varies across region and farm type (Vitale et al., 2009). Given the large number of cotton farmers, aggregate supply is modeled as a continuous function. The aggregate cotton production quantity (Q_l) and the aggregated input (Z_i) cost are calculated respectively as:

(1) $Q_l = \sum_{i=1}^{n} (Y_{ic} * X_{ic})$

(2) $Z_i = \sum_{i=1}^{n} (z_i * r_p)$

Where Y_{ic} is the cotton yield for the i^{th} farmer in kg/ha, X_{ic} is the area of cotton grown by the i^{th} farmer in hectares; z_i is the quantity of the urea used by the i^{th} farmer in kg/ha, and n is the total number of farmers.

The farmers are price takers and the parastatal exert their vertical control over the cotton market and choose both the input (r_p) and output (p_p) prices to maximize their profit according to Equation 3; however these prices are subject to the farmers maximizing their profit as described by Equation 4.

(3) $MaxPI = (p_w - p_p) * Q_l(p_p, r_p, \tau, \mu_m) - (r_w - r_p) * Z_i(p_p, r_p, \tau, \mu_m)$

Where $MaxPI$ is the parastatal maximum profit, p_w is the cotton lint price in the world market in \$/kg, r_w is the urea price in the world market in \$/kg, Q_l is the aggregate quantity of cotton lint in the local market in kg, p_p is the demand price the parastatal pay the farmers for the cotton lint in \$/kg, r_p is the price of urea the parastatal charges the farmers in \$/kg, Z_i is the aggregated urea quantity supplied to the farmers in the local market in kg/ha, and τ is a vector of food crops prices (cereals and vegetables), and μ_m is the price of maize in \$/kg. Maize is included because farmers can choose to either plant cotton or maize.

Given the urea (r_p) and cotton lint (p_p) prices, the farmers choose the area of cotton (X_{ic}) and maize (X_{im}) to plant, and the level of input (z_i) to maximize their profit as described by the following relationship:

(4) $MaxFI = p_p * Y_{ic}(z_i) * X_{ic}(p_p, r_p, \tau, \mu_m) + \mu_m * Y_{im}(z_i) * X_{im} - r_p *$

$z_i(p_p, r_p, \tau, \mu_m) + `\lambda_{land} * (\theta_{land} - \varphi_{ic} * X_{ic} - \varphi_{im} * X_{im})$

Where $MaxFI$ is the farmers maximum profit, Y_{ic} is the cotton yield of the i^{th} farmer in kg/ha, Y_{im} is the maize yield for the i^{th} farmer in kg/ha, X_{ic} is the area allocated to cotton by the i^{th} farmer in hectares, X_{im} is the area allocated to maize by the i^{th} farmer in hectares, λ_{land} is shadow prices of the land constraint, and θ_{land} is the level of land available for the i^{th} farmer, and φ_{ic} and φ_{im} are the levels of land required to produce X_{ic} and X_{im} for the i^{th} farmer, respectively.

For the farmer to engage in growing cotton the farmer's model has to satisfy a break even condition that is defined by the following Equation:

(5) $Break\ even_i = \left(0.4 * Y_{ic} * p_p\right) - (r_p * zi) \ \geq 0$

Where $Break\ even_i$ is the break-even point for farm type *i*, 0.4 is the ginning efficiency ratio, Y_{ic} is the cotton yield for the i^{th} farmer in kg/ha, p_p is the price the parastatal pay the farmers for the cotton lint in $/kg, r_p is the urea price the parastatal charges the farmers in $/kg, and z_i is the quantity of urea used by the i^{th} farmer.

4.1 First-Order Conditions

The structure of the output supply and input demand equations are explained for the situation where the input and output prices are set by the parastatal. In general, parastatals can choose to either subsidize or extract rents in a market. Using an illustrative example, with a single input (urea), there are four possible combinations, subsidizing or extracting rents in the input and output markets. The optimal choice depends on both the size of the market and the shape (elasticity) of the supply and demand curves. The exact relationships are obtained from the first order conditions (FOC).

The first order derivatives of the parastatal profit function with respect to p_p and r_p results in the following set of equations:

(6) $\frac{\partial \text{PI}}{\partial P_p} = -Q_l(p_p, r_p, \tau, \mu_m) + (p_w - p_p) * \frac{\partial Q_l(p_p, r_p, \tau, \mu_m)}{\partial P_p} - (r_w - r_p) * \frac{\partial Z_i(p_p, r_p, \tau, \mu_m)}{\partial p_p}$

$= 0$

(7) $\frac{\partial \text{PI}}{\partial r_p} = r_w * Z_i(p_p, r_p, \tau, \mu_m) - (r_w - r_p) * \frac{\partial Z_i(p_p, r_p, \tau, \mu_m)}{\partial r_p} + (p_w - p_p) * \frac{\partial Q_l(p_p, r_p, \tau, \mu_m)}{\partial r_p}$

$= 0$

The first term in Equation 6 is the marginal loss in revenue when the cotton lint domestic price (p_p) is increasing, equaling to the aggregated quantity transacted Q_l. This loss in revenue occurs since higher demand prices (p_p) reduce the parastatal price margin, decreasing the parastatal profit. The second term represents the marginal increase in revenue from enforcing pricing power on the output market, with magnitude proportional to the slope of the supply curve. When the cotton price (p_p) increases the aggregated quantity of cotton supplied (Q_l) increasing the parastatal profit. More elastic supply enables greater pricing power. The third term is unique to the vertical coordination problem; it represents how enacting pricing power on the output market has effects on the input market. When the parastatal increases the price paid (p_p) to the farmers the level of subsidy on urea decreases.

In Equation 7 the first term represents the marginal increase in revenue when the input price is subsidized, equaling to the aggregated quantity transacted Z_i. This increase in revenue is due to the increase of the cotton output as a result of the increased quantity of urea used. The second term represents the decrease in revenue as a result of subsidizing urea, with magnitude proportional to the slope of the urea supply curve. More elastic supply enables greater pricing power. Similar to Equation 3, the third term is also unique to the vertical coordination problem; it represents the how enacting pricing power on the input market has positive effects on the output market. When the parastatal subsidizes urea, the farmers use the optimal level of urea and produce at the physical optimum level increasing the quantity of cotton produced.

Taking the first derivatives of the farmers profit maximizing equation with respect to X_{ic}, X_{im}, z_i, λ_{land} results in the following set of Equations:

(8) $\frac{\partial(FI)}{\partial(X_{ic})} = p_p * Y_{ic} - \lambda_{land} * \varphi_{ic} = 0$

(9) $\frac{\partial(FI)}{\partial(X_{im})} = \mu_m * Y_{im} - \lambda_{land} * \varphi_{im} = 0$

(10) $\frac{\partial(FI)}{\partial(z_i)} = -r_p + p_p * Y_{ic} + \mu_m * Y_{im} = 0$

(11) $\frac{\partial(FI)}{\partial(\lambda_{l_{land}})} = \theta_{land} - \varphi_{ic} * X_{ic} - \varphi_{im} * X_{im} \geq 0$

In Equation 8 the first term represents the marginal increase in revenue when the domestic cotton price increases; stimulating the production of cotton bringing in more productive growers; the second term is the loss in revenue when the shadow prices of land increases. Similar to Equation 8, the first term in equation 9 represents the marginal increase in revenue when the domestic price of maize increases encouraging the farmers to increase the area of maize planted in place of cotton, and the second term is the marginal loss in revenue when the shadow prices of land increases For Equation 10 the first term is the marginal loss when the level of subsidy decreases meaning that the farmers have to pay a higher price for urea, and the second and third terms represent the increase in revenue when the cotton and maize output increases as a result of increase in the use of urea. Equation 11 is the land constraint.

CHAPTER V

DATA AND PROCEDURES

5.1 Data

The data used in this thesis come from two different sources. The cotton world price is taken from the National Cotton Council of America economics data center, and converted from cents per pound to dollars per kilogram. An average for the period of 2005-2013 of the "A" index[1] price is used (Table 1). The "A" index price is not adjusted to transportation and other transfer costs.

Table 1. Cotton - "A" index - Year Average prices

Year	"A" index Price ($/kg)
2005	1.26
2006	1.33
2007	1.64
2008	1.35
2009	1.72
2010	3.64
2011	2.20
2012	1.94
2013	1.98
Average	1.90

Source: National Cotton Council of America

[1] The "A" index price is a proxy of the world cotton price.

The average production costs and mean annual yields for the typical three farm types[2] are included in Tables 2 and 3, respectively. These data are taken from a survey that was developed and administered by INERA, the national agricultural institute of Burkina Faso over the summer and autumn of the years 2009, 2010 and 2011. Each year a sample of 180 farmers were randomly selected and surveyed. The sample is taken from ten villages from the three major cotton growing areas in Burkina Faso. The data are then averaged across the three different farm types in the three cotton growing areas.

Table 2. Summary of annual mean production costs averaged over three farm types across three production zones for the years 2009-2011.

	Large ($/ha)	Small ($/ha)	Manual ($/ha)
n=180/year			
		Bollgard II	
Insecticide	10.81	12.00	15.86
Seed Cost	60.07	61.19	58.25
Labor	147.92	142.08	138.83
Fert & Herb	154.54	149.91	133.26
Total Cost	373.34	365.18	346.20
		Conventional Cotton	
Insecticide	55.55	49.02	52.35
Seed Cost	12.10	12.43	12.87
Labor	140.48	139.13	132.92
Fert & Herb	152.47	151.55	136.97
Total Cost	360.59	352.13	335.11
		Cost Comparison: Bollgard II – Conventional Cotton	
BG II - Conventional	12.74	13.05	11.09

Source: INERA.

[2] The farm types are defined as: Large farms are the ones where at least two draft animals are used in the field operations; small farms only use one draft animal, and manual farms are those where all the field operations are done manually (Vitale et al., 2011).

Table 3. Annual mean cotton yields

Yield Item (Kg ha^{-1}) n=180/year	FARM TYPE Large	Small	Manual
Gene Type			
		2009	
BG II	1189	848	550
Conventional	1045	661	168
		2010	
BG II	1692	1964	1259
Conventional	791	1007	816
		2011	
BG II	1222	1153	1202
Conventional	983	969	974
		2009-2011 Average	
BG II	1368	1321	1004
Conventional	940	879	653

Source: INERA

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5.2 Procedures

To demonstrate the effect of the three alternatives to the parastatal vertical coordination in the total surplus distribution, equations 3 and 4 described in chapter IV are programmed in GAMS IDE™ (General Algebraic Modeling System), and maximized using a nonlinear programming algorithm.

Maize is included in the structural model as the farmers can choose to grow either maize or cotton, but it is excluded from the GAMS IDE™ program since at the time of this study there was not available detailed information on maize profitability to provide a decent comparison with cotton; instead the cotton break even condition is used, which is assumed to be a satisfactory measure to compare to maize profitability.

The total land available to the farmers is fixed at 1,200,000 hectares.

5.2.1 The Vertical coordination (Monopsony – Monopoly) case

With vertical coordination the farmers and the parastatal are linked by contractual agreements. The parastatal maintains legal monopoly in the input market and legal monopsony on the output market, setting both the urea price (r_p) charged to the farmers and the cotton lint price paid to the farmers (p_p).

Under this arrangement the parastatal surplus is maximized by solving the following objective function:

(12) $$Max\ PI = 0.4 * (p_w - p_p) * Q_{si} - \sum((r_w - r_p) * X_{ic} * z_i)$$

where 0.4 is the ginning efficiency ratio, used to compare the local market cotton quantity and the competitive market cotton quantity, p_w is cotton lint price in the competitive market in \$/kg, p_p is cotton lint price the farmers receive from the parastatal in \$/kg, r_w is the urea price in the competitive market in \$/kg, r_p is the urea price the parastatal charges the farmers in \$/kg Q_{si} is the aggregated expected cotton quantity supplied by farmer *i* in kg, X_{ic} is the area allocated to growing cotton by farmer i, and z_i is the level of urea used by farmer *i* in kg/ha.

With vertical coordination the parastatal profit maximization objective function is subject to the farmers satisfying the break even condition. The farmers break even condition requires that the farmer's revenue must be greater than or equal to production costs in order for them to continue producing cotton.

The break even condition is given by the following function:

(13) $$Break\ even_i = 0.4 * p_p * (a_i + b_i z_i - c_{i*} z_i^2) - r_p * z_i + 200 \geq 0$$

where *Break even*$_i$ is the break-even for farmer i, p_p is the demand price the parastatal pays the farmers for cotton lint in \$/kg, a_i is the intercept term of the yield response function for farmer *i* when no urea is used to grow cotton, b_i is the coefficient of the linear term of the yield response function for farmer i, c_i is the coefficient of the quadratic term of the yield response for farmer i, r_p is the urea price the parastatal charges the farmers in \$/kg, and 200 is the average marginal cost of growing cotton excluding the urea cost, in \$/ha.

The yield response function coefficients are estimated based on urea use and yield responses observed, and are determined as:

Manual Farms: a = 0, b = 6.3, c = -0.01;

Small Farms: a = 0, b = 7, c = -0.01;

Large Farms: a = 0, b = 7.8, c = -0.01;

where a_i is the intercept term of the yield response function for farmer *i* when no urea is used to grow cotton, b_i is the coefficient of the linear term of the yield response function for farmer i, and c_i is the coefficient of the quadratic term of the yield response function.

Given the coefficient estimates the yield response functions are defined as:

Manual Farms: $Y_{ic} = -0.01{z^2}_i + 6.3z_i$

Small Farms: $Y_{ic} = -0.01{z^2}_i + 7z_i$

Large Farms: $Y_{ic} = -0.01{z^2}_i + 7.8z_i$

where Y_{ic} is the cotton yield for the i^{th} farmer in kg/ha, and $z_i$is the level of urea used in kg/ha.

The level of urea used is a function of both urea and the cotton lint prices, given the urea (r_p) and cotton lint (p_p) prices set by the parastatal the level of urea used by the farmer is determined by resolving the following equation:

(14) $z_i = \frac{(p_p * b_i - r_p)}{(2 * c_i * p_p)}$

where z_i is the level of the urea used by farmer *i* in Kg/ha, *bi* is the coefficient of the linear term of the of the yield response equation for farmer type i, c_i is the coefficient of the quadratic term of the yield response for farmer i, p_p is the demand price the parastatal pays the farmers for cotton lint in $/kg, and r_p is the urea price the parastatal charges the farmers in $/kg.

The farmers are assumed to be price takers; the surplus by farmer type is determined by maximizing the following equation:

(15) $MaxFI_i = (p_p * Y_{ic} * X_{ic} - r_p + 200) * X_{ic}$

where $MaxFI_i$ is the maximum surplus for farmer *i*, $p_p$is the cotton lint price the parastatal pays the farmers in $/kg, Y_{ic} is the cotton yield for farmer *i* in kg/ha, X_{ic} is the area allocated to grow cotton by farmer *i*, r_p is the urea price the parastatal charges the farmers in $/kg, and 200 is the average marginal cost of growing cotton excluding the urea cost, in $/ha.

The total farm surplus is determined by summing the farm surplus across the total number (n) of farms,

(16) $TotalFI = \sum_i^n MaxFI_i$

The marginal cost is calculated as:

(17) $MC_i = \frac{(Q_{si} * p_p - MaxFI_i)}{Q_{si}}$

where MC_i is the marginal cost of growing cotton for farm *i*, p_p is the cotton lint price the parastatal pays the farmers in $/kg, and $MaxFI_i$ is the maximum surplus for farmer *I*, Q_{si} is the aggregated expected cotton quantity supplied by farmer *i* in kg.

In all of the four market structures analyzed the aggregated cotton supply is determined using equation 1 described in chapter IV.

5.2.2 *The Monopoly - Competition case*

The first alternative to the parastatal vertical coordination is to allow for the parastatal to keep monopoly control of the input market, while the farmers are allowed to sell their cotton production at the competitive market price. With monopoly control the parastatal sets the urea price, and the cotton price received by the farmers is linked to the competitive market price.

The parastatal surplus in the monopoly-competitive case is determined as:

(18) $$Max\ PI = 0.4 * \sum((r_w - r_p) * X_{ic} * z_i)$$

where 0.4 is the efficiency ginning ratio, and it used to compare the local market cotton quantity and the competitive market cotton quantity, r_w is the urea price in the competitive market in $/kg r_p is the urea price the parastatal charges the farmers in $/kg, X_{ic} is the area allocated to growing cotton by farmer *i*, and z_i is the level of urea used by farmer *i* in kg/ha.

Under the monopoly competition case the parastatal also maximizes the surplus subject to the farmers satisfying the break even condition. In this case the break even condition is given by the following function:

(19) $$Break\ even_i = 0.4 * p_w * (a_i + b_i z_i - c_{i*} z_i^2) - r_p * z_i + 200 \geq 0$$

where *Break even*$_i$ is the break-even for farmer *i*, p_w is the cotton lint price in the competitive market in $/kg, a_i is the intercept term of the yield response function for farmer *i* when no urea is used to grow cotton, b_i is the coefficient of the linear term of the yield response function for farmer *i*, c_i is the coefficient of the quadratic term of the yield response for farmer i, r_p is the urea price the parastatal charges the farmers in $/kg, and 200 is the average marginal cost of growing cotton excluding the urea cost, in $/ha.

Given the cotton lint competitive market price (p_w) and the urea price set by the parastatal (r_p), the level of urea used is determined as follows:

(20) $$z_i = \frac{(p_w * b_i - r_p)}{(2 * c_i * p_w)}$$

where z_i is the level of the urea used by farmer i in Kg/ha, bi is the coefficient of the linear term of the of the yield response equation for farmer type i, c_i is the coefficient of the quadratic term of the yield response for farmer i, p_w is the demand price for the cotton lint in the competitive market in $/kg, and r_p is the urea price the parastatal charges the farmers in $/kg.

Under the monopoly-competitive case the farmers sell the cotton at the competitive market price (p_w) with the urea price being set by the parastatal. The farmers' maximum surplus is given by the following equation:

(21) $$MaxFI_i = (p_w * Y_{ic} * X_{ic} - r_p + 200) * X_{ic}$$

where $MaxFI_i$ is the maximum surplus for farmer type i, p_w is the cotton lint price in the competitive market in $/kg Y_{ic} is the cotton yield for farmer i in kg/ha, X_{ic} is the area allocated to grow cotton by farmer i, r_p is the urea price the parastatal charges the farmers in $/kg, and 200 is the average marginal cost of growing cotton excluding the urea cost, in $/ha.

The total farm surplus is determined by summing the farm surplus across the total number (n) of farms, and is calculated by the following equation:

(22) $TotalFI = \sum_{i}^{n} MaxFI_i$

The marginal cost is determined by the following equation:

(23) $MC_i = \frac{(Q_{si} * p_w - MaxFI_i)}{Q_{si}}$

where MC_i is the marginal cost of growing cotton for farm *i*, p_w is the cotton lint price in the competitive market in $/kg, and $MaxFI_i$ is the maximum surplus for farmer *i*, Q_{si} is the aggregated expected cotton quantity supplied by farmer *i* in kg.

5.2.3 <u>The Competition - Monopsony case</u>

The second alternative to the parastatal vertical coordination is to allow for the parastatal to remain as a monopsonist in the cotton buying while the farmers can procure the urea on the competitive market. Under this arrangement the farmers urea price is linked to the competitive market price while the parastatal sets the cotton lint price (p_p) they pay to the farmers. The parastatal exercises market power in the output market and has to set a cotton price (p_p) that satisfies the farmers break even conditions in order to make it attractive for the farmers to grow cotton.

The parastatal surplus under the competition-monopsony case is maximized by solving the following equation:

(24) $Max\ PI = 0.4 * (p_w - p_p) * Q_{si}$

where 0.4 is the efficiency ginning ratio, and it used to compare the local market cotton quantity and the competitive market cotton quantity, p_w is cotton lint price in the competitive market in \$/kg, p_p is cotton lint price the farmers receive from the parastatal in \$/kg, Q_{si} is the aggregated expected cotton quantity supplied by farmer *i* in kg.

The farmers break even condition for this case is given by the following equation:

(25) $$Break\ even_i = 0.4 * p_p * (a_i + b_i z_i - c_{i*} z_i^2) - r_w * z_i + 200 \geq 0$$

where *Break even*$_i$ is the break-even point for farmer *i*, p_p is the demand cotton lint price the parastatal pays the farmers in \$/kg, a_i is the intercept term of the yield response function for farmer *i* when no urea is used to grow cotton, b_i is the coefficient of the linear term of the yield response function for farmer *i*, c_i is the coefficient of the quadratic term of the yield response for farmer *i*, , r_w is the urea price in the competitive market in \$/kg, and 200 is the average marginal cost of growing cotton excluding the urea cost, in \$/ha.

Given the cotton lint price set by the parastatal (p_p) and the urea price in competitive market (r_w) the level of urea used is determined as follows:

(26) $$z_i = \frac{(p_p * b_i - r_w)}{(2 * c_i * p_p)}$$

where z_i is the level of the urea (urea) used by farmer *i* in Kg/ha, b_i is the coefficient of the linear term of the of the yield response equation for farmer type *i*, c_i is the coefficient of the quadratic term of the yield response for farmer *i*, p_p is the monopsonistic demand price the parastatal pays the farmers for the cotton lint in \$/kg, and r_w is the urea price in the competitive market in \$/kg.

Under the competitive-monopsony case the farmers procure the inputs in the competitive market, and are required to sell the cotton to the parastatal,

(27) $MaxFI_i = (p_p * Y_{ic} * X_{ic} - r_w + 200) * X_{ic}$

where $MaxFI_i$ is the maximum surplus for farmer type i, p_p is the cotton lint price the parastatal pays the farmers in \$/kg, Y_{ic} is the cotton yield for farmer *i* in kg/ha, X_{ic} is the area allocated to grow cotton by farmer *i*, r_w is the urea price in the competitive market in \$/kg, and 200 is the average marginal cost of growing cotton excluding the urea cost, in \$/ha.

The total farm surplus is determined by summing the surplus across the total number (n) of farms, and is calculated by the following equation:

(28) $TotalFI = \sum_i^n MaxFI_i$

The marginal cost is calculated as:

(29) $MC_i = \frac{(Q_{si} * p_p - MaxFI_i)}{Q_{si}}$

where MC_i is the marginal cost of growing cotton for farm i, p_p is the cotton lint price the parastatal pays the farmers in \$/kg, and $MaxFI_i$ is the maximum surplus for farmer *i*, Q_{si} is the aggregated expected cotton quantity supplied by farmer *i* in kg.

5.2.4 <u>The Competition (free market) case</u>

The last option is to allow for a competitive market where the farmer's prices are directly linked with the competitive market prices, with the farmer's surplus being directly affected by the changes in the competitive market price. Hence the parastatal profit is equal to zero. It is assumed that under this conditions the farmers are free of credit constrains, being able to participate in the competitive market.

The farmer's surplus is determined by the following equation:

(30) $MaxFI_i = (p_w * Y_{ic} * X_{ic} - r_w + 200) * X_{ic}$

where $MaxFI_i$ is the maximum surplus for farmer type i, $p_w$is the cotton lint price in the competitive market in \$/kg,Y_{ic} is the cotton yield for farmer *i* in kg/ha, X_{ic} is the area allocated to grow cotton by farmer *i*, r_w is the urea price in the competitive market in \$/kg, and 200 is the average marginal cost of growing cotton excluding the urea cost, in \$/ha.

The total farm surplus is determined by summing the surplus across the total number (n) of farms, and is calculated by the following equation:

(31) $TotalFI = \sum_i^n MaxFI_i$

In the competitive market case the urea use is a function on the cotton lint price and urea price in the competitive market; it is given by the following equation:

(32) $z_i = \frac{(p_w * b_i - r_w)}{(2 * c_i * p_w)}$

where z_i is the level of the urea (urea) used by farmer *i* in Kg/ha, *bi* is the coefficient of the linear term of the of the yield response equation for farmer type *i*, c_i is the coefficient of the quadratic term of the yield response for farmer *I*, p_w is the cotton lint demand price in the competitive market in \$/kg, and r_w is the urea price in the competitive market in \$/kg.

The marginal cost is determined by the following equation:

$$\textbf{(33)} \quad MC_i = \frac{(Q_{si} * p_w - MaxFI_i)}{Q_{si}}$$

where MC_i is the marginal cost of growing cotton for farm i, p_w is the cotton lint price in the competitive market in $/kg, and $MaxFI_i$ is the maximum surplus for farmer *i*, Q_{si} is the aggregated expected cotton quantity supplied by farmer *i*.

5.2.5 The GAMS program:

```
*Model
Set
F_Area /A_small,A_medium,A_large/
Urea /Z_small,Z_medium,Z_large/
F_Surplus /FRM_Surpl_small,FRM_medium,FRM_large,FRM_Surpl_Total,Total_Surplus/
Yields /YLD_small,YLD_medium,YLD_large/
Ql /Q_S_small,Q_S_medium,Q_S_large,Q_S_Total/
Marginal /MC_Small,MC_medium,MC_large/
i /1*50/
Type /small,medium,large/
;
alias(type, type1);
Equations
Profit
Profit1
Profit_Farm
Profit_SFarm
Supply
Farmer_EZ
Farmer_LZ(Type)
Comp_OP
Comp_IP
P_o_min
P_o_max
P_i_min
P_i_max
Break_even
Break_1even
Break_2even
Break_even_(Type)
```

```
Land
Land_max
Land_max1
Land_max2
Land_max_(Type);
Parameter
P_o_world
P_i_world
a,b,c
a1,b1,c1
a2,b2,c2
a_(Type),b_(Type),c_(Type)
Area
Yield_calc
Yield(Type)
PI_Farm
PI_Agg_Farm
alpha_0
alpha_1
beta
L_Supply
PI_MZ_ha
Z_opt
Brk_Even
PI_Calc
Pct_Area(Type)
Farm_Agg_Surplus(Type)
Tot_Farm_Agg_Surpl
Total_Surplus
Q_S_Farm(Type)
MC(Type);
a_("small") = 0;a_("medium") = 0; a_("large") = 0;
b_("small") = 6.3;b_("medium") = 7; b_("large") = 7.8;
c_("small") = 0.01;c_("medium") = 0.01; c_("large") = 0.01;
Pct_Area("small") = 0.15;Pct_Area("medium")= 0.70;Pct_Area("large")= 0.15;
Area=500000;
alpha_0=200000;
alpha_1=7000;
beta=6.5;
L_Supply=1200000;
PI_MZ_ha=-10000;
Brk_Even = 200;
Variables
PI
PI_MFarm
PI_SFarm;
```

```
Positive Variables
Q_S
Q_D
P_o
P_i
Z
Z1
Z2
Z_(Type)
Area_X
Area_X1
Area_X2
Area_(Type)
;
* Data prices are in $/Kg
P_o_world = 1.90;P_i_world=0.50;
Q_S.L=3;
P_o.L=0.001;
Supply .. Q_S =E=
              Sum(Type, Area_(Type)*(a_(Type) + b_(Type)*Z_(Type) -
            c_(Type)*Z_(Type)*Z_(Type) )    )  ;

Comp_OP .. P_o =E= P_o_world;
Comp_IP .. P_i =E= P_i_world;
Farmer_EZ .. Z =E= (P_o*b - P_i)/(2*c*P_o);
Farmer_LZ(Type) .. Z_(Type) =L= b_(Type)/(2*c_(Type));
Profit .. PI =E= 0.4*(P_o_world-P_o)*Q_S  - sum(Type, (P_i_world-
            P_i)*Area_(Type)*Z_(Type))
              + (L_Supply-sum(Type, Area_(Type)))*PI_MZ_ha;
Profit1 .. PI =E= 0.4*(P_o_world-P_o)*Q_S
                -sum(Type, (P_i_world-P_i)*Area_(Type)*Z_(Type))
              + (L_Supply-sum(Type, Area_(Type)))*PI_MZ_ha;
Profit_Farm .. PI_MFarm =E= 0.4*P_o_world*(a + b*Z - c*Z*Z) - P_i_world*Z;
Profit_SFarm .. PI_SFarm =E= 0.4*P_o_world*Q_S
                - sum(Type, P_i_world*Area_(Type)*Z_(Type)-Area_(Type)*Brk_Even)
                + (L_Supply-sum(Type, Area_(Type)))*PI_MZ_ha ;

Break_even .. 0.4*P_o*(a + b*Z - c*Z*Z) - P_i*Z - Brk_Even =G= 0 ;
Break_1even .. 0.4*P_o*(a1 + b1*Z1 - c1*Z1*Z1) - P_i*Z1 - Brk_Even =G= 0 ;
Break_2even .. 0.4*P_o*(a2 + b2*Z2 - c2*Z2*Z2) - P_i*Z2 - Brk_Even =G= 0 ;
Break_even_(Type)  .. 0.4*P_o*(a_(Type)  + b_(Type)*Z_(Type) -
            c_(Type)*Z_(Type)*Z_(Type) ) - P_i*Z_(Type) - Brk_Even =G= 0 ;
P_o_min .. P_o =G= 0.00000000000001;
P_o_max .. P_o =L= 3;
P_i_min .. P_i =G= 0.00000000000001;
```

```
P_i_max .. P_i =L= 1.50;
Land .. Area_X =E= alpha_0 + alpha_1*((P_o)**(beta));
Land_max .. Area_X =L= 0.25*L_Supply;
Land_max1 .. Area_X1 =L= 0.50*L_Supply;
Land_max2 .. Area_X2 =L= 0.25*L_Supply;
Land_max_(Type) .. Area_(Type) =L= Pct_Area(Type)*L_Supply ;
* Parastatal setting both price and quantity
Model Vertical /Supply,Land_max_,Break_even_,P_o_min, P_o_max,P_i_min,
        P_i_max,Farmer_LZ,Profit/;
Model Monopoly /Supply,Land_Max_,Break_even_,Comp_OP,P_o_min,P_o_max,P_i_min,
        P_i_max,Farmer_LZ,Profit/;
Model Monopsony /Supply,Land_Max_,Break_even_,Comp_IP,P_o_min,P_o_max,P_i_min,
        P_i_max,Farmer_LZ,Profit/;
Model Competitive /Supply,Profit_SFarm,Land_max_,P_o_min,P_o_max,P_i_min,
        Farmer_LZ,P_i_max/;
Put Supply_Response; Put "      ";Put "P_o_world ";Put "P_i_world ";Put "P_o ";Put "P_i ";
Loop(Yields,
Put Yields.TL;
);
Loop(Ql,
Put Ql.TL;);
Loop(Marginal,
Put Marginal.TL;);
Put /;
Put Result; Put "      ";Put "P_o_world ";Put "P_i_world ";Put "P_o ";Put "P_i ";
Loop(F_Area,
Put F_Area.TL;
);
Loop(Urea,
Put Urea.TL;
);
Put /;
Put Result1; Put "      ";Put "P_o_world ";Put "P_i_world ";Put "P_o ";Put "P_i ";
Put "PI.L    ";Put "Q_S  ";
Loop(F_Surplus,
Put F_Surplus.TL;Put "   ";
);
Put /;
* Vertical case
Solve Vertical maximizing PI using NLP;
Put Result; Put " "; Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put
        P_i.L;Put " ";
Loop(Type,
Put Area_.L(Type); Put " ";
);
Loop(Type,
```

```
Put Z_.L(Type); Put " ";
);
Put "    ";Put /;
Put Result1;
Put " "; Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Put PI.L;Put "  ";Put Q_S.L;
Tot_Farm_Agg_Surpl = 0;
Loop(Type,
  Farm_Agg_Surplus(Type) =  Area_.L(Type)*(Break_even_.L(Type) - Brk_Even);
  Tot_Farm_Agg_Surpl = Tot_Farm_Agg_Surpl + Farm_Agg_Surplus(Type);
  Put Farm_Agg_Surplus(Type);  Put "   ";
);
Put Tot_Farm_Agg_Surpl;Put "   ";
  Total_Surplus  = PI.L + Tot_Farm_Agg_Surpl;
Put Total_Surplus;
Put /;

Put Supply_Response;
Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Loop(Type,
Yield(Type) = a_(Type) + b_(Type)*Z_.L(Type) - c_(Type)*Z_.L(Type)*Z_.L(Type);
Q_S_Farm(Type) = Yield(Type)*Area_.L(Type);
MC(Type) = (Q_S_Farm(Type)*P_o.L  -  Farm_Agg_Surplus(Type))/Q_S_Farm(Type)  ;
Put Yield(Type); Put "   ";
);
Loop(Type, Put Q_S_Farm(Type); Put "   ";   ); Put Q_S.L;Put "    ";
Loop(Type, Put MC(Type); Put "   ";   );
Put /;
Put Result;
* Monopoly case
Solve Monopoly maximizing PI using NLP;
Put Result;
Put Result; Put " "; Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put
         P_i.L;Put " ";
Loop(Type,
Put Area_.L(Type); Put "    ";
);
Loop(Type,
Put Z_.L(Type); Put "    ";
);
Put /;
Put Result1;
Put " "; Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Put PI.L;Put "  ";Put Q_S.L;
Tot_Farm_Agg_Surpl = 0;
Loop(Type,
```

```
  Farm_Agg_Surplus(Type) =  Area_.L(Type)*(Break_even_.L(Type) - Brk_Even);
  Tot_Farm_Agg_Surpl = Tot_Farm_Agg_Surpl + Farm_Agg_Surplus(Type);
  Put Farm_Agg_Surplus(Type); Put "   ";
);
Put Tot_Farm_Agg_Surpl;Put "   ";
  Total_Surplus  = PI.L + Tot_Farm_Agg_Surpl;
Put Total_Surplus;  Put "   ";
Put /;
Put Supply_Response;
Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Loop(Type,
Yield(Type) = a_(Type) + b_(Type)*Z_.L(Type) - c_(Type)*Z_.L(Type)*Z_.L(Type);
Q_S_Farm(Type) = Yield(Type)*Area_.L(Type);
MC(Type) = (Q_S_Farm(Type)*P_o.L  -  Farm_Agg_Surplus(Type))/Q_S_Farm(Type)  ;
Put Yield(Type); Put "   ";
);
Loop(Type, Put Q_S_Farm(Type); Put "   ";   ); Put Q_S.L;Put "    ";
Loop(Type, Put MC(Type); Put "   ";   );
Put /;
Put Result;
* Monopsony case
Solve Monopsony maximizing PI using NLP;
*Solve Vertical maximizing PI using NLP;
Put Result; Put "      ";
Put Result; Put " "; Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put
           P_i.L;Put " ";
Loop(Type,
Put Area_.L(Type); Put "    ";
);
Loop(Type,
Put Z_.L(Type); Put "    ";
);
Put /;
Put Result1;
Put " "; Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Put PI.L;Put "  ";Put Q_S.L;
Tot_Farm_Agg_Surpl = 0;
Loop(Type,
  Farm_Agg_Surplus(Type) =  Area_.L(Type)*(Break_even_.L(Type) - Brk_Even);
  Tot_Farm_Agg_Surpl = Tot_Farm_Agg_Surpl + Farm_Agg_Surplus(Type);
  Put Farm_Agg_Surplus(Type); Put "   ";
);
Put Tot_Farm_Agg_Surpl;Put "   ";
  Total_Surplus  = PI.L + Tot_Farm_Agg_Surpl;
Put Total_Surplus;  Put "   ";
Put /;
```

```
Put Supply_Response;
Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Loop(Type,
Yield(Type) = a_(Type) + b_(Type)*Z_.L(Type) - c_(Type)*Z_.L(Type)*Z_.L(Type);
Q_S_Farm(Type) = Yield(Type)*Area_.L(Type);
MC(Type) = (Q_S_Farm(Type)*P_o.L  -  Farm_Agg_Surplus(Type))/Q_S_Farm(Type)  ;
Put Yield(Type); Put "   ";
);
Loop(Type, Put Q_S_Farm(Type); Put "   ";   ); Put Q_S.L;Put "    ";
Loop(Type, Put MC(Type); Put "   ";   );
Put /;
Put Result;
* Competitive case
Solve Competitive maximizing PI_SFarm using NLP;
Put Result; Put "      "; Put P_o_world;Put "    ";Put P_i_world;Put "    ";Put P_o.L;Put "    ";Put
            P_i.L;Put "    ";
Loop(Type,
Put Area_.L(Type); Put "    ";);
Loop(Type,
Put Z_.L(Type); Put "    ";);
Put Result1;
Put " "; Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Put PI_SFarm.L;Put "    ";Put Q_S.L;Put "    ";
Yield(Type) = a_(Type) + b_(Type)*Z_.L(Type) - c_(Type)*Z_.L(Type)*Z_.L(Type);
Q_S_Farm(Type) = Yield(Type)*Area_.L(Type);
Tot_Farm_Agg_Surpl = 0;
Loop(Type,  Farm_Agg_Surplus(Type) =  0.4*P_o_world*Q_S_Farm(Type) -
                P_i_world*Area_.L(Type)*Z_.L(Type) -Area_.L(Type)*Brk_Even  ;
  Tot_Farm_Agg_Surpl = Tot_Farm_Agg_Surpl + Farm_Agg_Surplus(Type);
  Put Farm_Agg_Surplus(Type);Put "   ";);
Put Tot_Farm_Agg_Surpl;Put "   ";   Total_Surplus  = PI.L + Tot_Farm_Agg_Surpl;
Put Total_Surplus;
Put /;
Put Supply_Response;
Put P_o_world;Put " ";Put P_i_world;Put " ";Put P_o.L;Put "  ";Put P_i.L;Put " ";
Loop(Type,
Yield(Type) = a_(Type) + b_(Type)*Z_.L(Type) - c_(Type)*Z_.L(Type)*Z_.L(Type);
Q_S_Farm(Type) = Yield(Type)*Area_.L(Type);
MC(Type) = Brk_Even/Yield(Type);
Put Yield(Type); Put "   ";); Loop(Type, Put Q_S_Farm(Type); Put "   ";   ); Put Q_S.L;Put "
            ";
Loop(Type, Put MC(Type); Put "   ";   );
Put /;
```

CHAPTER VI

RESULTS AND DISCUSSION

6.1 The Vertical coordination (Monopsony – Monopoly) case

With vertical coordination, contractual agreements require the cotton farmers to procure inputs provided by the parastatal and the parastatal has rights to purchase all of the cotton grown by the farmers. The area of cotton planted varies across the farm types and is assumed to remain constant across the four different market arrangements, with the manual and large farms planting 180,000 hectares of cotton each, while small producers account for the largest share of the area planted (70%), with a total of 840,000 hectares of cotton. This could be explained by the fact the parastatal does not price discriminate and sets a minimum price that allows for all farmers to satisfy the break even condition to ensure they engage in growing cotton.

It is assumed that the farmers are price takers and that in the world market cotton lint is bought at $1.9/kg and the input, urea, is sold at $0.50/kg. (For cases below where it is assumed that producers receive the market price, it is also assumed that transportation and handling costs are zero. This simplification will be relaxed in future research.) The results in Table 4 show that with vertical coordination, the parastatal sets the cotton lint price below the world market price and completely subsidizes the urea price, offering it to farmers free of charge to ensure the participation by each of the three farmer types and the use of an optimal level of urea; however, the parastatal extracts rents from them on the output market. The farmers receive $0.50/Kg for cotton lint, which is $1.40/kg below the world cotton lint price.

Table 4. Output and input prices set by the parastatal.

Market structure	p_p ($/kg)	r_p ($/kg)
Vertical coordination	0.5	0
Monopoly – Competition	1.9	1.5
Competition – Monopsony	0.86	0.5
Competition	1.9	0.5

With vertical coordination, a total economic surplus of $683.54 million is generated per year, and the parastatal collects the largest share of the benefits (91.98%); the manual farmers break even and do not receive any surplus (0%), the small farmers receive 5.31%, and the large farmers 2.71% of the total economic surplus. The high share collected by the parastatal under vertical coordination reflects the fact that the parastatal manipulates the input and output prices and extracts rents from the output market by setting the cotton price paid to the farmers at $0.5/Kg, below the competitive market price ($1.9/Kg). Furthermore, Equation 7 of the first order condition for the parastatal profit maximization suggests that the parastatal can enforce market power on the input market and use subsidies to provide the urea free of charge to the farmers to guarantee that they use an optimal level of urea to increase the cotton production, and extract rents on the output market.

Regarding the surplus distribution the model predicts that the distribution of the total economic surplus among the parastatal and cotton farmers is uneven along the four market structures considered (Table 5).

Table 5. Estimates of economic surplus and distribution under the four market structures.

	Surplus by Farm type (Million $)					
Market structure	Parastatal	Manual	Small	Large	Total farm	Total
Vertical coordination	628.74	0	36.27	18.53	54.8	683.5
	91.98%	0%	5.31%	2.71%	8.02%	100%
Monopoly– Competition	420.9	14.69	173.04	66.77	254.5	675.4
	62.32%	2.18%	25.62%	9.89%	37.68%	100%
Competitive– Monopsony	615.89	0	37.09	22.58	59.67	675.5
	91.17%	0%	5.49%	3.34%	8.83%	100%
Competition	0	72.9	473.9	138.5	685.3	685.3
	0%	10.63%	69.16%	20.20%	100%	100%

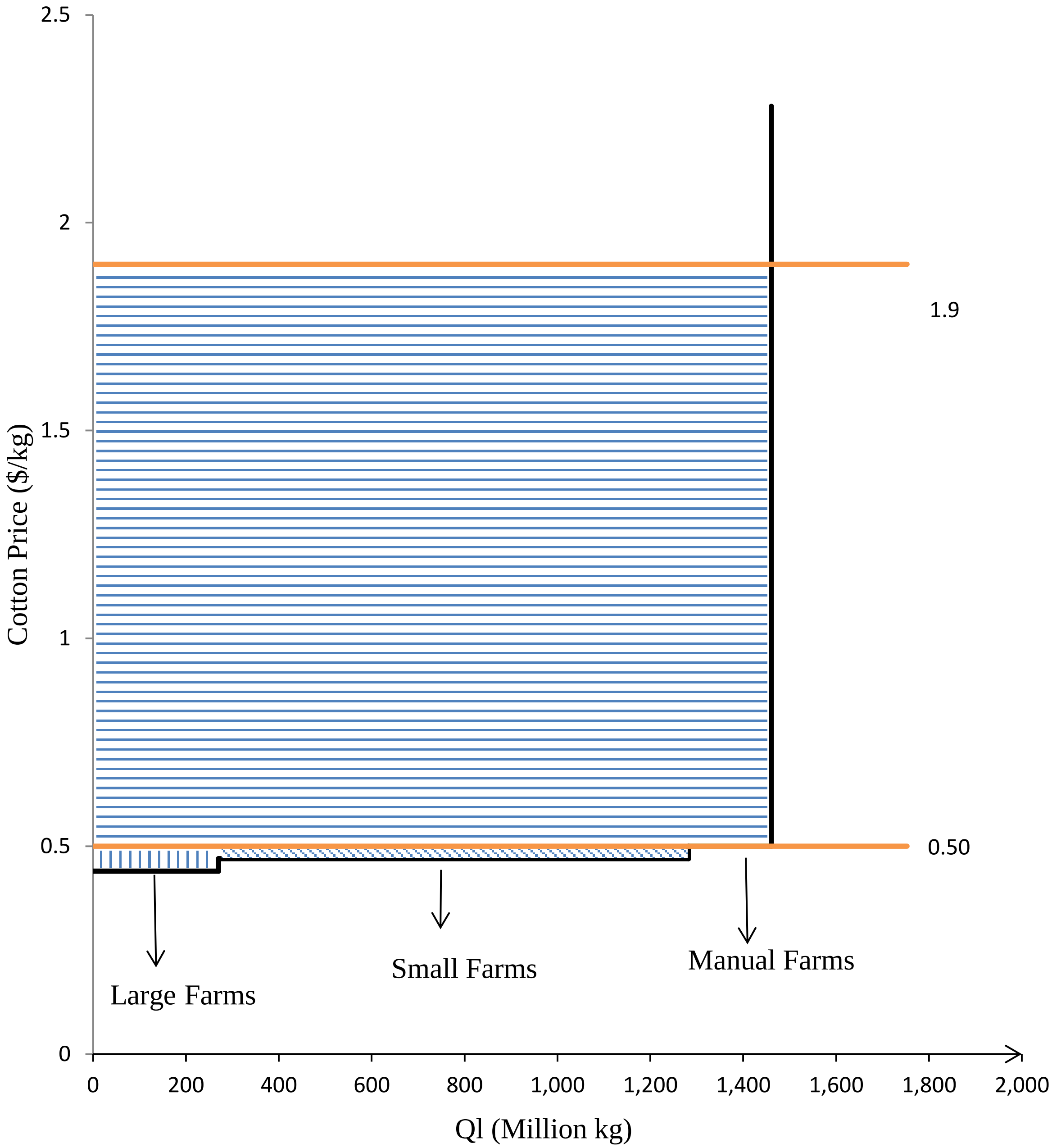
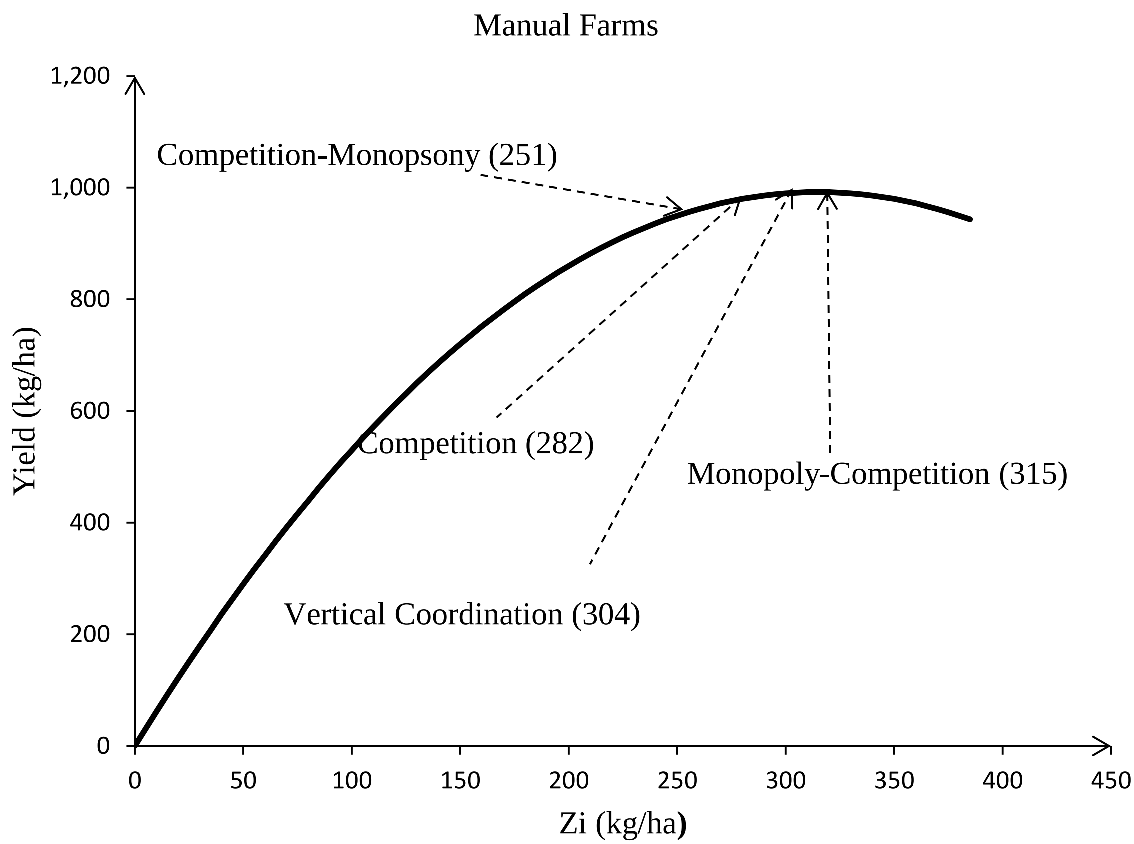


Figure 9. Surplus distribution under vertical coordination.

Figure 9 shows the surplus distribution under the vertical coordination case, in which the parastatal exercises market power on both input and output markets. As reported in Table 5 the large farmers' surplus is equal to the area represented by the vertical stripes and corresponds to a surplus of $18.53 million. The small farmers' surplus is equal to the area of the diagonal stripes, which is equal to a surplus of $36.27 million. The manual farmers do not generate any surplus. The parastatal surplus is equal to the area represented by the horizontal stripes.



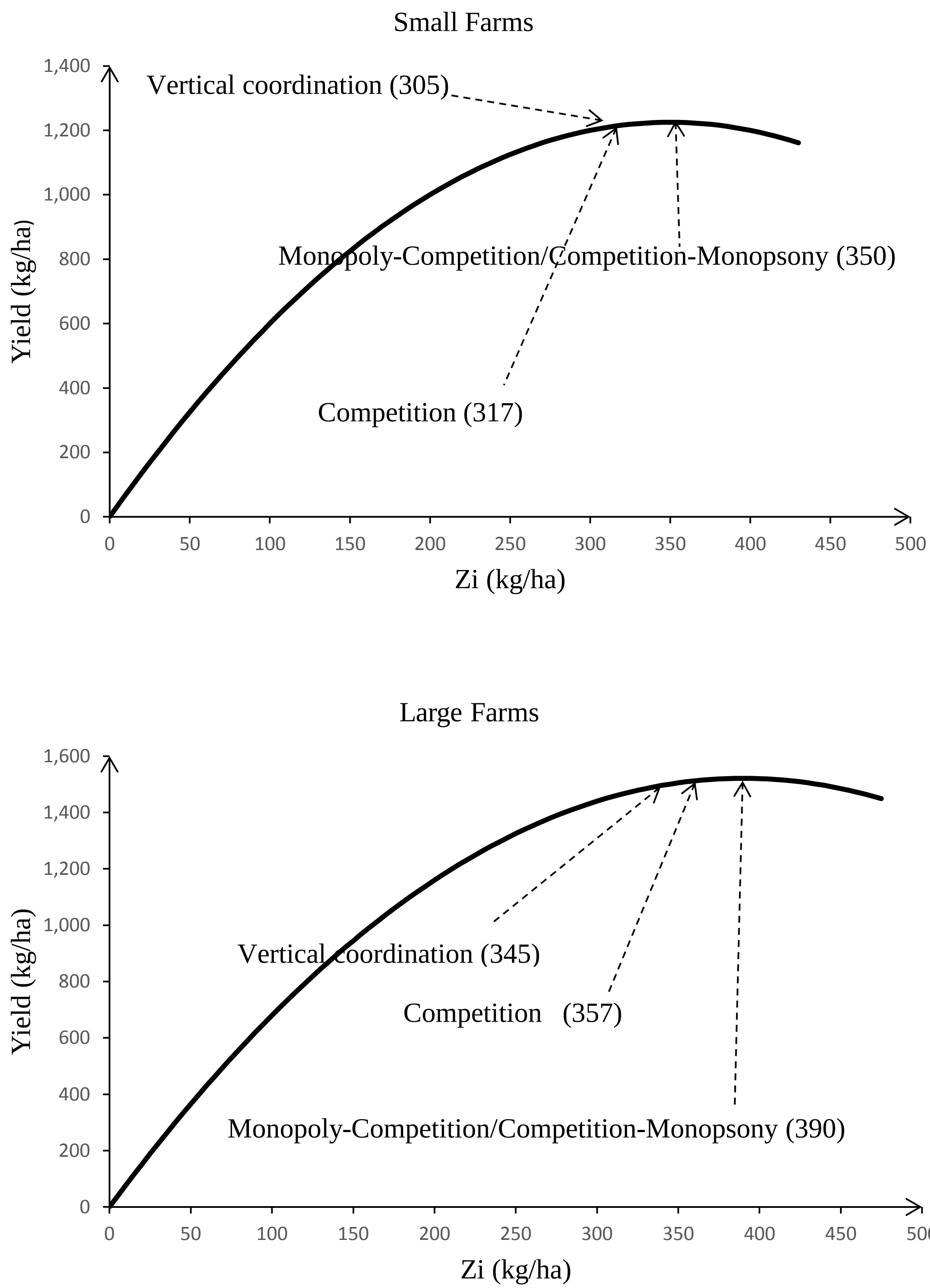


Figure 10. Yield and urea use by farm type across the four market arrangements (values in parenthesis are the level of urea used).

The maximum production level of urea use varies across farm type. For the manual farms it is 315 kg/ha, for the small farms it is 350 kg/ha, and for the large farms it is 390 kg/ha, corresponding to maximum yields of 992 kg/ha, 1,225 kg/ha, and 1,521 kg/ha in the manual, small, and large farms respectively (Figure 10). The parastatal maximizes profit subject to the farmers satisfying the breakeven condition. The urea allocation per farm type varies across the four different market structures; the small and the large farmers tend to behave similarly, while the manual famers behave differently when it comes to urea allocation.

With vertical coordination, in which the total farm surplus is the smallest compared to the other market structures (Table 5), the farmers use urea below the maximum production level. The small farms use 304 Kg/ha, which is close to the maximum production level, and produce 991 kg of cotton per hectare. The small and large farmers also use less than the maximum production level of urea, using 305 kg/ha and 345 kg/ha and producing 1,205 and 1,501 kg of cotton per hectare, respectively (Figure 9).

6.2 The Monopoly - Competition case

One alternative to the parastatal vertical coordination arrangement in the cotton sector in West and Central Africa is to let the farmers to sell their production in the competitive market so they receive the competitive cotton price ($1.9/kg), and let the parastatal exercise monopoly control of the input market. Given this arrangement the parastatal would charge the producers $1 more above the urea world price ($0.5/kg), and the producers would have to pay $1.5/kg of urea. Despite the higher urea price charged by the parastatal the higher cotton price in the competitive market ($1.9/kg) makes growing cotton attractive to the farmers (Table 4).

The results in Table 5 show that with this arrangement the total economic surplus generated compared to vertical coordination case decreases by $8.1 million to a total of $675.4 million. The distribution of the surplus remains uneven, however the parastatal captures less than captured under the vertical coordination since the parastatal no longer exercises market power on the output market, and the farmers increase their share of the total economic surplus as a result of the higher competitive cotton price ($1.9/kg) received. The parastatal share decreases from 91.98% to 62.32%, and the total farm surplus increases from 8.02% to 37.68%. The larger beneficiaries of the higher cotton price received in the competitive market ($1.9/kg) are the manual farmers with their share of the surplus increasing from 0% to 2.18% relative to the vertical coordination case (Table 5). The small and large farmers capture 25.62% and 9.89% of the total surplus, respectively.

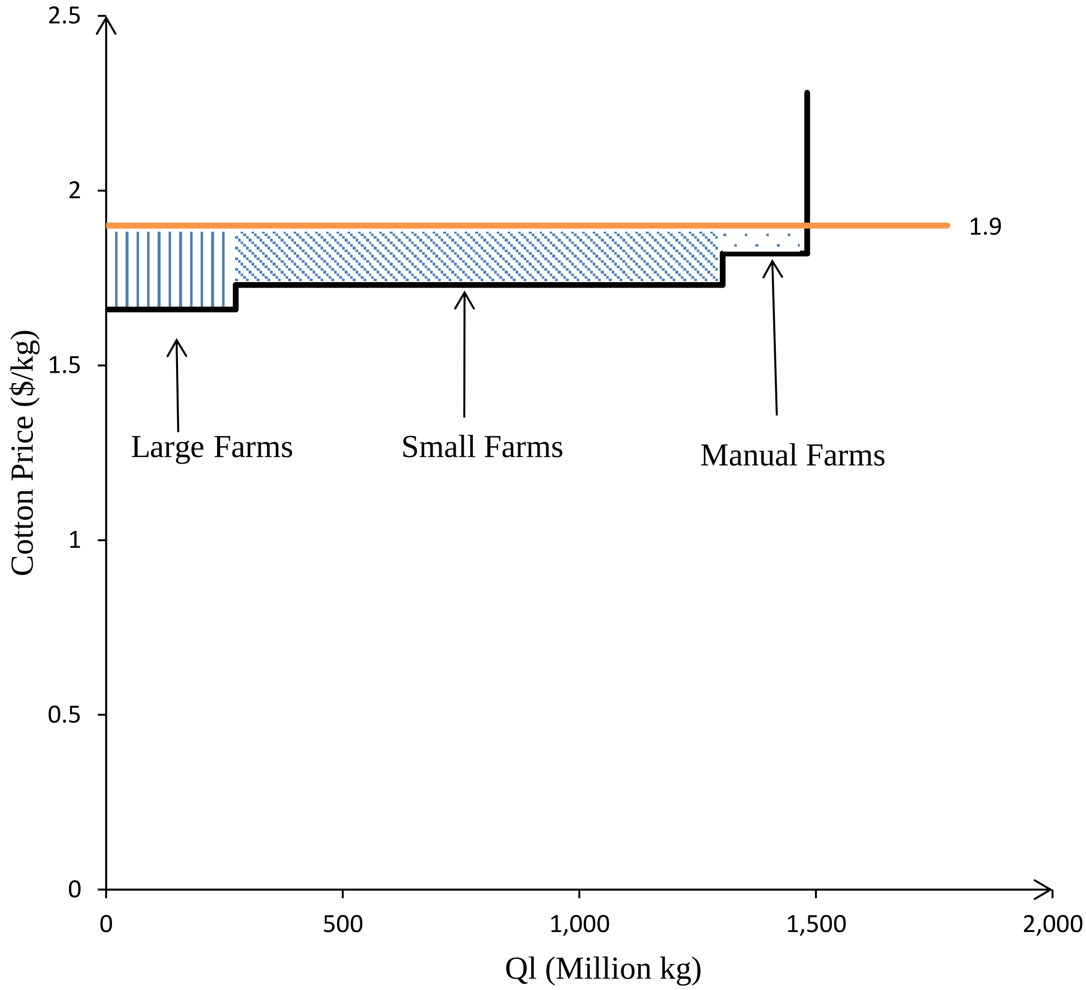


Figure 11. Surplus distribution under the monopoly-competition case.

Figure 11 represents the surplus distribution under the monopoly-competition case where the parastatal as monopoly control of the urea price and the farmers sell their cotton at the competitive price. The large farmers' surplus is equal to the area represented by the vertical stripes and corresponds to a surplus of $66.77 million as reported in Table 5. The small farmers' surplus is equal to the area of the diagonal stripes, which is equal to a surplus of $173.04 million. The manual farmers' surplus is equal to the area with the dots, which is equal to a surplus of $14.69 million.

Under this arrangement the parastatal maximizes its surplus by extracting rents from the input market; however, all of the farm types produce cotton using the amount of urea that maximizes cotton production, because of the higher cotton price received in the competitive market. This allows them to increase farm surplus (Table 5).

6.3 The Competition - Monopsony case

Another alternative to the parastatal vertical coordination is to allow the farmers to procure inputs on the world market and let the parastatal act as a monopsonist in the cotton buying. In theory in a monopsony situation the price received by the farmers should be equal to the competitive market price ($1.9/kg) adjusted to tax and other transfer costs (World Bank, 2000). Under these conditions the parastatal pays the farmers $0.86/kg of cotton lint which is 36 cents more than the price offered under vertical coordination case (Table 4).

The total economic surplus decreases to $675.56 million, which is $7.99 million less than in the vertical coordination case. The parastatal captures the largest share of the surplus (91.17%), and the remainder of the total economic surplus is shared among the small (5.49%) and the large (3.34%) producers, with the manual farmers being penalized by the parastatal monopsonistic price and, similar to the vertical coordination case, capturing none of the total surplus generated. The results of the model show that the parastatal surplus is higher when it is allowed to exercise market power and extract rents on the output market rather than on the input market, because the output market is larger than the input market. The farmers are negatively affected by the monopsonistic price of $0.86/kg the parastatal pays for the cotton; however, because farmers receive 36 cents/kg more with this arrangement the total farm surplus increases by 0.81% compared to the vertical coordination case.

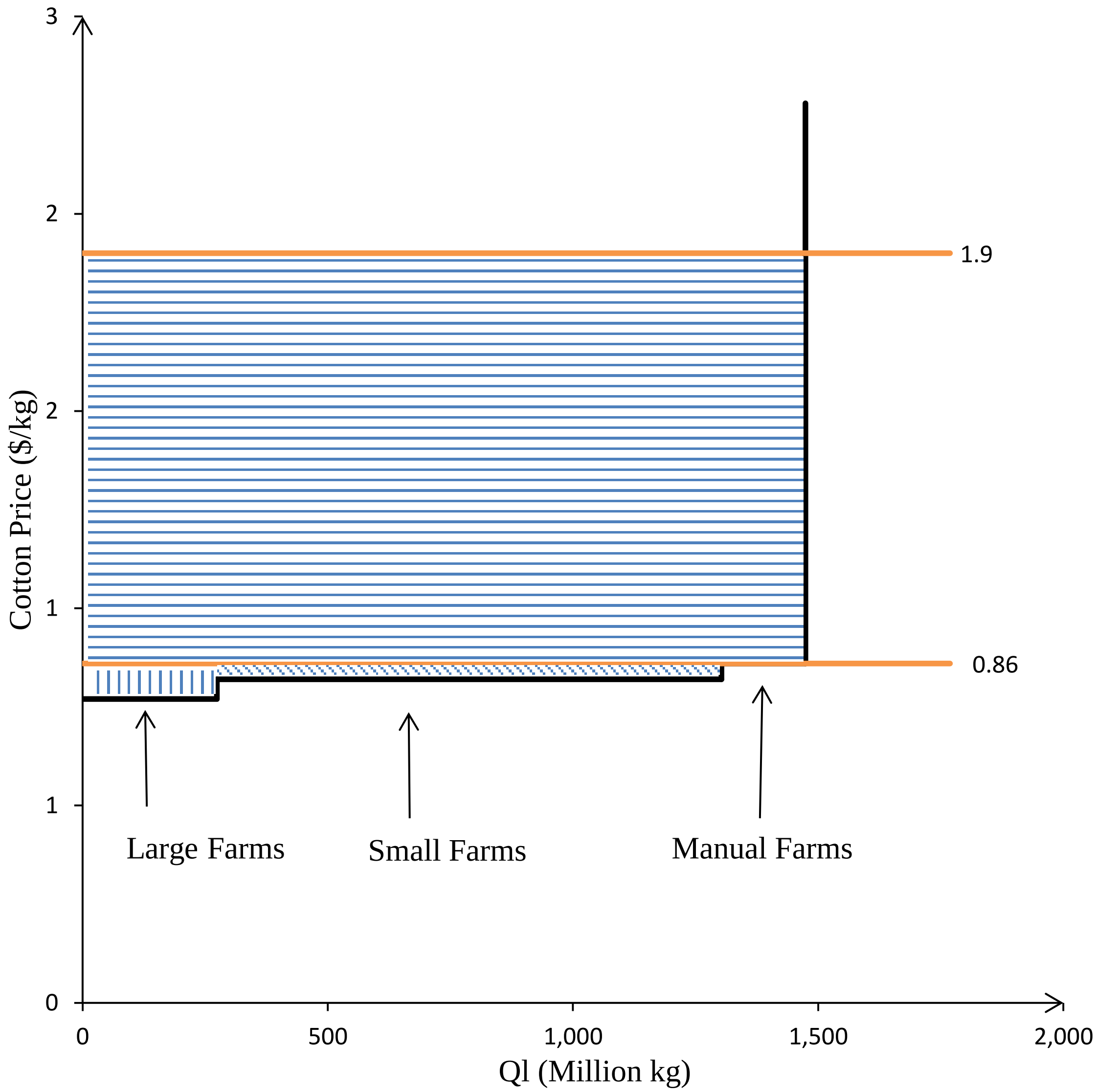


Figure 12. Surplus distribution under the competition-monopsony case.

Figure 12 shows the surplus distribution under the competition-monopsony; where the parastatal acts as a monopsonist and the farmers procure urea in the competitive market. As reported in Table 5, the large farmers' surplus is equal to the area represented by the vertical stripes and corresponds to a surplus of $22.58 million. The small farmers' surplus is equal to the area of the diagonal stripes, which is equal to a surplus of $37.09 million. The manual farmers do not generate any surplus. The parastatal surplus is equivalent to the area represented by the horizontal stripes.

Whit this arrangement the farmers buy urea at the competitive market price ($0.5/kg), the small and the larger farmers produce at the maximum production level of urea use. (This production level is a result of an assumption in the model that producers choose production levels based on break-even, rather than profit-maximizing use of urea amounts; the producers use the amount of urea allocated to them by the parastatal. A profit-maximizing producer would use less urea and produce some amount less than the maximum.) The manual farmers use 251 kg/ha, which is below their maximum production level, producing 951 kg/ha of cotton (Figure 10). The level of urea used by the manual farmers can be explained by the fact that these farmers are capital constrained and under these conditions they breakeven not generating any surplus.

6.4 <u>The Competition (free market) case</u>

The third alternative to the parastatal vertical coordination is to completely liberalize the cotton sector allowing for the farmers to procure inputs and sell their production in the competitive market. In a competitive market where the farmers benefit from higher price incentives, receiving $1.9/kg of cotton lint and purchasing urea at $0.5/kg, the total economic surplus is maximized with all of the benefits accruing to the farmers. The total economic surplus reaches a maximum of $685.3 million (Table 5), of which 10.63% accrue to the manual farmers, 69.16% to the small farmers, and 20.2% to the large farmers; hence the parastatal surplus is zero (Table 5). These results are similar to the findings of Gourex and Macrea (2003) and Poulton (2004) that found on their studies that on the first years of the cotton market privatization the farmers benefit from higher price stimulus and maximize their surplus.

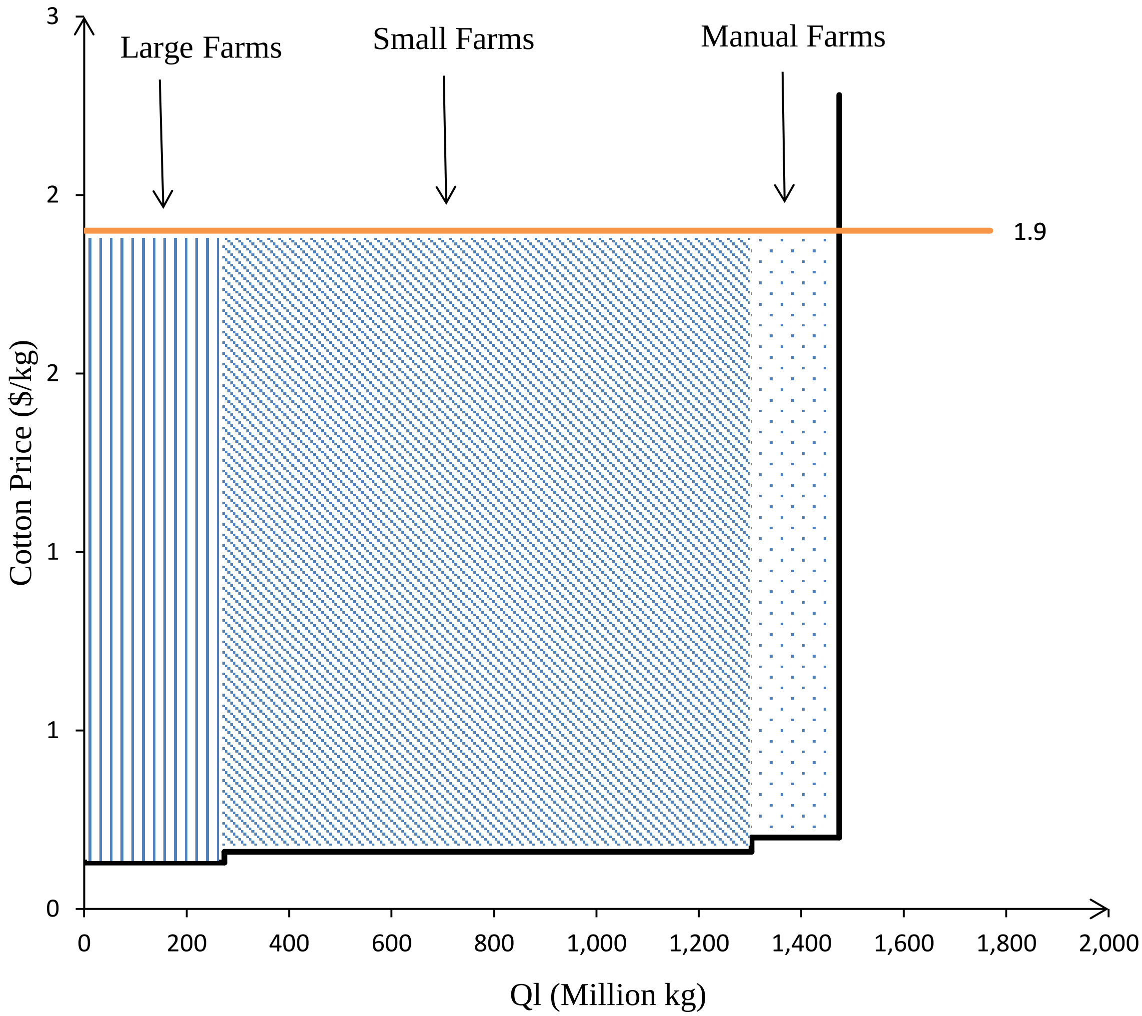


Figure 13. Surplus distribution in the competitive market.

The surplus distribution in a competitive market is shown is figure 13. As reported in Table 5, the large farmers' surplus is equal to the area represented by the vertical stripes and corresponds to a surplus of $138.5 million. The small farmers' surplus is equal to the area of the diagonal stripes, which is equal to a surplus of $473.9 million. The manual farmers' surplus is equal to the area with the dots, which is equal to a surplus of $72.9 million.

In competitive conditions the three farmer types use urea levels below the physical maximum (Figure 10) and maximize the total farms surplus (Table 5). The manual farmers use 282 Kg/ha, the small 317 kg/ha, and the large 357 kg/ha of urea corresponding to yields of 981 kg/ha, 1214 kg/ha and 1510 kg/ha respectively.

6.5 *Summary/Comparisons*

The results of this thesis show that the parastatal captures the largest shares of the total economic surplus when allowed to enforce market power on both input and output market or each of them separately. The parastatal extracts more rents from the output market relatively to the input market, under vertical coordination the parastatal adjusts the input and output prices to extract rents from the output rather than from the input market. This result fails in reject the working hypothesis of this thesis that says that more rents are extracted from the output rather than input market.

The farmers are better off with market privatization, with privatization the farmers benefit from higher price incentives in the competitive market. Furthermore, the farmer's surplus increases when they are allowed to receive the competitive market cotton price. For instances, the farmers gain more when they can sell their production in the world market even when the parastatal is allowed to exercise monopoly control of the input market and over charges the farmers for urea. This result could indicate that the output market is bigger in size compared to the input market.

The manual farmers are more sensitive to the cotton lint price; for instance they lose their surplus when the parastatal acts as a monopsonist and pays the producers poor prices compared to the competitive market prices.

The urea use varies across the four market structures; however the farmers tend to use the optimal level of urea (Figure 8) motivated by different incentives across the different market structures proposed. For instance in the vertical coordination case urea is supplied free of charge to guarantee that the producers use the optimum level of urea and produce close to maximum production level; in the monopoly-competition case the incentive is the higher cotton price received in the world market; on the competition monopsony case the farmers pay less for urea and receive a higher cotton price (Table 4) compared to the vertical coordination case; and finally on the free market case the farmers are motivated by the higher cotton price incentives received in the competitive market.

CHAPTER VII

CONCLUSIONS

Privatization of the cotton sector in West and Central Africa has been proposed to remove market power and other market distortions to increase the sector welfare (World Bank, 2000). This thesis assessed the potential economic consequences of different market structures for the cotton sector in West and Central Africa using a structural model. The results show that the primary beneficiaries of departing from the current parastatal vertical coordination in favor of alternative competitive market structures in cotton sector in West and Central Africa are the farmers, by reason of the higher price received for cotton lint in the competitive market. The model shows that the economic surplus distribution among the farmers and the parastatal is unequal across the four market structures analyzed.

The results from the model establish that the share of the cotton price captured by the farmers is more relevant to the change of the farmers' surplus than is the urea price. The higher the share of cotton price received by the farmer the higher is the farmers' surplus. For instance, when it comes to partial privatization, the farmers are better off with a monopoly-competitive structure in which they are allowed to sell their production at the competitive market price with the parastatal maintaining monopoly control of the input market when compared to a competitive-monopsony structure where the parastatal is allowed to act as a monopsonist and let the farmers procure for urea at the competitive market price. The manual farmers are the ones who benefit the most among the three producer's types; unlike the other farm types under monopsony cases they simply break even and do not generate any surplus but the scenario inverts when they are allowed to receive the competitive cotton price and generate surplus.

The parastatal extracts more in the output market than in the input market. With vertical coordination the parastatal captures the largest share of the total economic surplus and if the cotton market is privatized this scenario is inverted and the farmers capture 100% of the total economic surplus.

This analysis does not address the performance or the degree of inefficiencies associated with the parastatal or destiny of the parastatal profit, since corruption and poor management have been an issue (Kaminski et al., 2009). It would be expected that in a competitive market the share of the parastatal surplus under vertical coordination would be transferred to the farmers; however, this is less likely to happen in West and Central Africa countries due to other institutional constraints (Vitale et al., 2009).

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