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Burkina Faso
What is Driving Cotton Production
Stochastic Frontier Approach for Panel Data

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1 US$	=	CFAF 500

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ABBREVIATIONS AND ACRONYMS

CFA	*Communauté Financière d'Afrique*
CWIQ	Core Welfare Indicator Questionnaire
EBCVM	*Enquête Base sur la Condition des Vie des Ménages*
EICVM	*Enquête Intégrale sur les Condition de Vie des Ménages*
EP	*Enquête Prioritaire*
FCFA	Franc CFA
GDP	Gross Domestic Product
HCPI	Harmonized Consumer Price Index
HDI	Human Development Index
HDRO	Human Development Report Office
INSD	Institut National de la Statistique et de la Demographie
LDC	Less Developed Countries
MDG	Millennium Development Goals
OLS	Ordinary Least Squares
SCADD	*Stratégie pour une Croissance Accélérée et une Développement Durable*
SSA	Sub-Saharan Africa
UNDP	United Nations Development Programme

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ABSTRACT

This paper explores the determinants of cotton production in Burkina Faso using the agricultural panel survey Enquête Permanent Agricole (EPA) conducted by the Ministry of Agriculture between 2002 and 2007. It finds that over the period of the analysis there was little improvement in yield and the expansion of cotton output was driven almost entirely by expansion in area cultivated. Yields are most sensitive to rainfall and the elasticity of yields to rainfall shocks is 0.6, while the elasticity of output to land input is 1.2. This suggests that over the period of analysis, there was very little technical change in cotton production in Burkina Faso. To sustain growth of cotton production, intensification and promotion of widespread adoption of higher yielding seeds, such as Bt cotton, which was introduced in 2008 will be necessary.

1. What is Driving Cotton Production in Burkina Faso Stochastic Frontier Approach for Panel Data

A. BACKGROUND: BURKINA FASO, A COUNTRY OF SHOCKS?

1.1 **Like most Sub-Saharan economies, agricultural sector plays a major role in Burkina Faso's economy.** It employs nearly 80 percent of the working population, contributes an average of 33 percent to GDP and 90 percent to the country's exports. Despite fluctuations due to weather instability, agricultural sector has been growing at an average rate of 5.2 percent over the past 10 years. Crop production accounts for 60 percent of overall agriculture value added while livestock production and other sub-sectors (fishing, hunting and forestry) account respectively for 28 percent and 12 percent on average. Although the performance of all sub-sectors in agriculture were strong, crop production played an important role because on account of acreage expansion and its dominant position in the value addition the sector. On average, cultivated areas increased by 2.3 percent annually, although per capita acreage has remained virtually constant over the past 15 years.

1.2 **The design and implementation of an effective strategy for sustainable expansion of cotton output in Burkina Faso requires an understanding of the main factors influencing cotton production**. Previous studies have focused on macro level drivers of cotton production. However, there is a lot to learn by looking at the decision making process of small scale cotton growers on inputs, cropping system, market participation, and budget and time allocation. Therefore, in this study, we use household level data from the panel agricultural survey in Burkina Faso, *Enquête Permanent* to analyze the main features of cotton production in Burkina.

1.3 **The results indicate that yields, measured as output per hectare, remained stagnant and too dependent on rainfall throughout the period.** However, production rose at a rate of about 2 percent per year. We show that most of the output can be attributed to households bringing more land under cotton cultivation. According to our estimates the elasticity of output to land input is 1.2, meaning that 1 percent increase in cotton acreage increases cotton output by 1.2 percent. The increase in acreage can come about in two ways: new entrants taking up uncultivated lands, and existing producers expanding their acreage, although we do not distinguish the two in the paper. Other inputs such as fertilizers also increase output but the magnitudes are too small.

B. REGIONAL CONTEXT FOR COTTON PRODUCTION

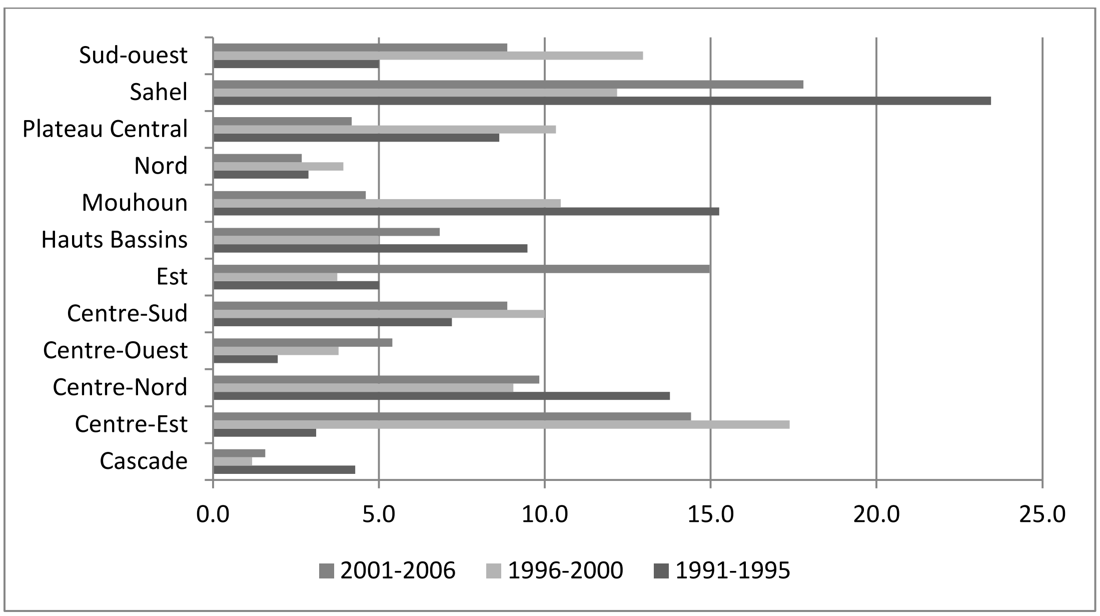
1.4 **Cotton plays an important part in West and Central Africa's economic growth as it represents the largest source of export receipts for the majority of countries.** According to the Organization for Economic Cooperation and Development (OECD), approximately 16 million people depend directly or indirectly on cotton cultivation (OECD, 2006a). Although none of the West African countries plays a major role in the international cotton trade, West and Central Africa as a whole is the world's third largest exporter (OECD, 2006b), averaging nearly one million tons over the 2000/01–2004/05 period, or 13 percent of global production, behind the USA (2.5 million tons, or 37 percent) and Central Asia (1.2 million tons, or 17 percent). Eight countries in West and Central Africa - Benin, Burkina Faso, Cameroon, Chad, Cote d'Ivoire, Mali, Senegal and Togo - produce 99 percent of all cotton in the region (Pratt and Yu, 2008). Several studies suggest that recent success in the expansion of cotton production in the region has been driven largely by bringing more land under cotton over the last 20-30 years (Ton 2001; SWAC Secretariat/OECD 2005; Kaminski, 2011). For example, Benin increased area under cotton from 41,000 to 382,000 hectares in 20 years, from 1984 to 2003. Other West African countries also expanded land allocated to cotton production very rapidly between 1984 and 2003: Togo (9.6 percent), Burkina Faso (8.6 percent), Mali (8.1 percent), Cameroon and Ghana (5.6 percent), and Ivory Coast (4.3 percent) (Falck-Zepeda, Horna and Smale, 2007). The increase in acreage has not been followed by increase in yield. According to a report by the UN Economic Commission for Africa (ECA, 2009), the reasons for the slow increase in yields include the dominance of rain-fed production, inadequate post-harvest handling technologies, limited use of improved seeds, fertilizers, and management and utilization of by-products. In addition, efficiency has also been hampered by poor infrastructure, high cost of seeds and pesticides, and institutional barriers like single-channel monopolies for inputs and monopolistic competition among ginneries (Poulton, 2007).

1.5 **In 2005 Burkina Faso became the leading West African producer of cotton, producing 450,000 to 750,000 tons of seed cotton between 2005 and 2010.** Moreover, for a couple of years, that is 2006 and 2007, Burkina Faso was the leading cotton producer and exporter among all African countries. The cotton boom in the 2000s increased cotton's share of GDP from around 4 percent in the 1980s to 12 percent in 2008. The increase in production has been credited to underappreciated, but successful, institutional reforms. These reforms included strengthening farmers' groups before partially liberalizing input and output markets. In the first wave of institutional reforms, the government committed not to interfere with management of SOFITEX, the national cotton parastatal company, and established a plan to recapitalize the company (Kaminski et al., 2009). In addition, a market-based producer pricing setting mechanism which aligned domestic and world prices was established. To reduce excessive volatility, a producer floor price that is based on the 5-year moving average of world prices, was set (Yartey, 2008). Recent revisions have moved further to strengthen the alignment between the producers' floor price and the international price. More specifically, the price is now set as a 3 year moving average (rather than 5 year average) to make risk sharing between the producers and the ginners more balanced. At the same time, a smoothing fund is set up to finance the deviations of the actual price from the producer floor price: when world prices are very low, the fund pays the ginners and when they are high, the fund is replenished. Meanwhile additional reforms have sought to align marketing performance by ginning companies.

1.6 **These reforms led to substantial job growth.** About 700,000 people, comprising mostly family members of cotton growers find employment in the sector. Incomes have increased and poverty levels are believed to have come down in cotton growing areas. The cotton growing regions of Cascades, Hauts Bassin and Centre Ouest have some of the lowest poverty levels. Furthermore, cereal production is also believed to have expanded aided by a deliberate policy of ginners providing cereal inputs to cotton farmers and farmers diverting some of the inputs such as fertilizer provided for cotton to cereal production (Kaminski et al.,2009; Yartey, 2008). However, the reforms were less successful at raising yields. Productivity growth continued to be low for the period because cotton production continued to rely on low-input intensity. Moreover, cotton production is heavily influenced by rainfall fluctuations, burdened with high input costs, low capital intensity and be poorly served by inadequate and ineffective extension services. For instance, between 1991 and 2006, government spending on crop production accounted for almost half – or 49 percent - of the total government spending in the agricultural sector compared to only 2.3 percent for agricultural research. More generally, both the composition of spending and efficiency of spending may have had a role to play in observed yield outcomes.

1.7 **Maps 1 (a-f) present the geographic distribution of yield gaps for major crops in Burkina Faso, while map 1 (b) displays these yield gaps specifically for cotton.** The yield gap is the difference between potential yield and the yield actually observed, where the highest yield in the region is used as proxy for potential yield**.** Overall, between 1996 and 2006, the weighted average[1] yield gap varied between 4.6 percent in Kénédougou in Hauts Bassins to 66.5 percent in Kourweogo in Plateau Central. For individual key crops (cotton, maize, millet, sorghum and niébé), the distribution of yield gaps varies widely across provinces and regions**.** As shown, the most productive cotton growing areas are in the south and southwestern parts – that is, Cascades, Hauts Bassins and Centre-Sud Regions – of the country. Figure 1.1 shows regional shares of government spending on agriculture between 1991 and 2006. When contrasted with the distribution of yield gaps for cotton, there is no clear strong relationship. Since cotton accounts for 50-60 percent of all agricultural export from Burkina, one would expect a stronger investment in the sector that should be reflected in agriculture spending.

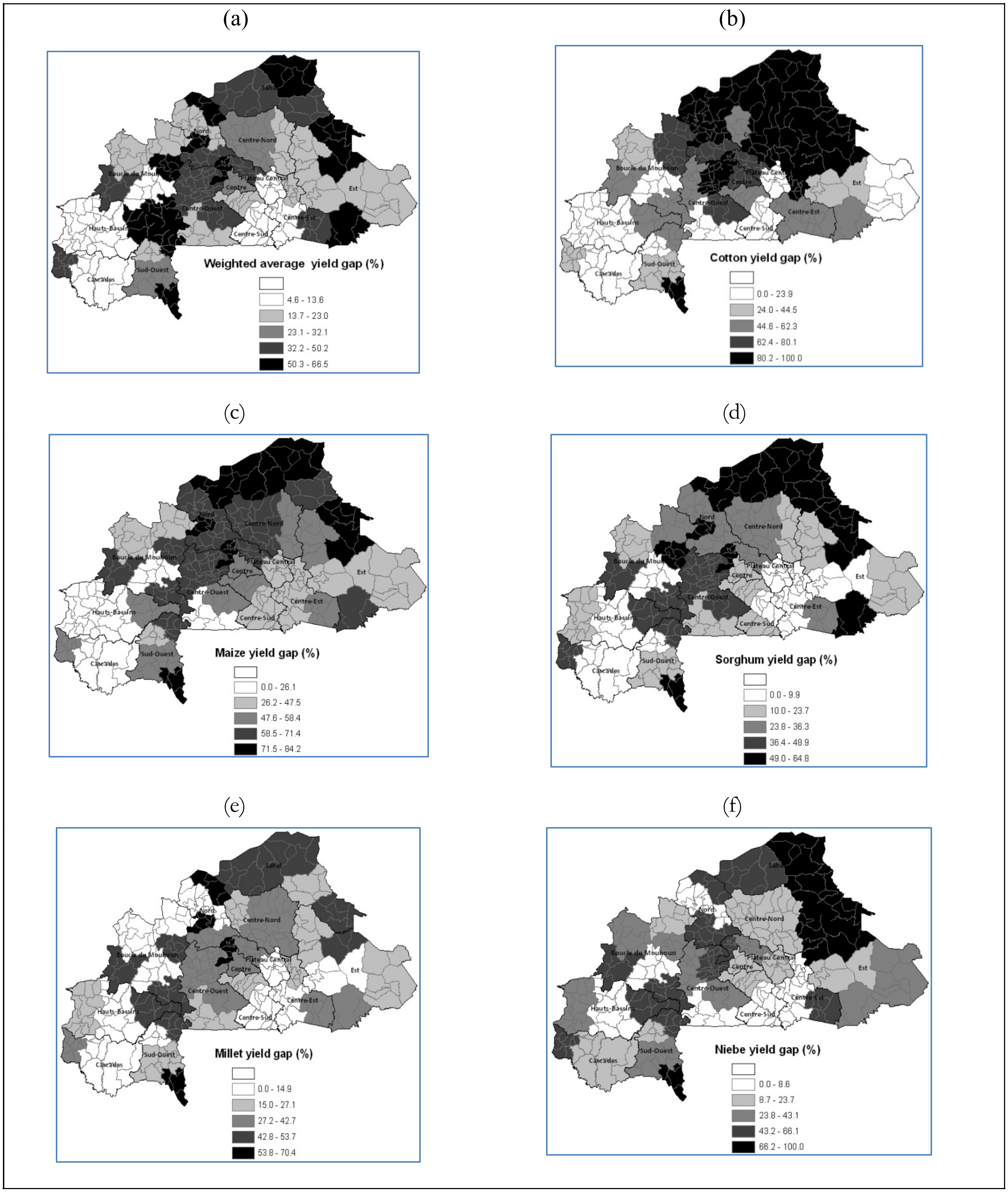
Figure 1.1: Agricultural budget allocation by regions (%)



Source: Authors' using DGPSA (2008) data.

[1] Crops include groundnuts, cotton, fonio, yam, maize, millet, niebe, sweet potatoes, rice, sesame, soya, sorghum and vouandzou; the share of each crop production is used as weight.

Figure 1.2: Maps 1 (a-f): Crop yield gap (%)



Source: Authors' computation.

1.8 **The observed increase in cotton production in Burkina Faso between 2002 and 2007 suggests that institutional and policy reforms and government spending would have had non-negligible impacts.** Unfortunately, we do not have government spending data other than at the regional level and what we have is not broken down into spending on specific crops, which would be preferred. Similarly, we cannot identify the cotton farmers by the private companies that serve them. Finally, the pricing reforms affected all farmers, so their true impact cannot be isolated. With these limitations, this study looks only at the effect of inputs and decisions that were made at the household level. However, we add rainfall patterns at provincial level (analysis at lower levels of disaggregation are planned). In the next section we briefly describe the method we use – stochastic production function using panel data.

C. METHODOLOGY

1.9 In this paper, we consider a stochastic production function (Battese and Coelli, 1995; Kumbhakar and Lovell, 2000) of the following form:

(1) $$q_{it} = f(x_{it}, t; \beta)\varepsilon_{it} exp(v_{it})$$

where $i = 1,\ldots, N$, represents agricultural households, t represents time trend, q_{it} is a production vector $(n \times 1)$ at time period t, x_{it} is the input vector $(1 \times k)$, at time period t, β is the $(k \times 1)$ vector of parameters to be evaluated, and ε_{it} represents the efficiency of household i, with $0 < \varepsilon_{it} \leq 1$. If ε_{it} = 1, then household i is achieving optimal production with respect to technology $f(x_{it}, \beta)$. However, if $0 < \varepsilon_{it} < 1$, then household i is failing to gain the maximum possible benefit from input (x_i), which means the production level is sub-optimal. Furthermore, the production of household i is also affected by random shocks, $v_{it} \sim N^+(0, \sigma_v^2)$.

1.10 The production technology stated in equation (1) can be written in logarithmic form:

(2) $$lnq_{it} = \beta_0 + \sum_{j=1}^{k-1} \beta_j lnx_{ijt} + ln\varepsilon_{it} + v_{it}.$$

Letting $u_{it} = -ln\varepsilon_{it}$, it follows that,

(3) $$lnq_{it} = \beta_0 + \sum_{j=1}^{k-1} \beta_j lnx_{ijt} - u_{it} + v_{it}.$$

The growth rate of output can be decomposed into contribution from the growth of inputs versus productivity change, and can be specified as,

(4) $$\dot{q}_{it} = \sum_{j=1}^{k-1} \beta_j \dot{x}_{ijt} + T\dot{F}P_{it},$$

TFP is the Total Factor Productivity and its growth can be decomposed further into technical change (TC) and technical efficiency (TE). To estimate technical change we follow a common practice where technical change is defined as the marginal change in output with respect to time trend

(5) $$TC = \frac{\partial f(x,t;\beta)}{\partial t}.$$

However, technical efficiency is defined as the ratio of observed output for the i-th farmer relative to its potential output and given by

(6) $$TE_{it} = \frac{q_{it}}{\exp[f(x_{it},t;\beta)+v_{it}]} = \exp(-u_{it}),$$

where $u_i \sim N^+(\mu, \sigma_\mu^2)$.

In the empirical results to follow we would be interested in the technical change and technical efficiency. The latter tells us whether the farmers are maximizing output given the existing technology. The former will tell us whether cotton production in Burkina Faso has adopted modern techniques and is driven by technological changes. But first we describe the data.

D. DATA DESCRIPTION

1.11 **We use *Enquête Permanent Agricole* (EPA) conducted by the Ministry of Agriculture of Burkina Faso. This is a unique panel of agricultural households that began in 1994.** Although the data has many attractive features: a long panel and focused on rural population, it is limited in many ways. One weakness is that there appears to be substantial attrition. Table 1.1 shows the levels of attrition and the inclusion of new households. Attrition rate varies between zero percent in 2005 and 100 percent in 2001. The latter reflects the fact that the Ministry replaced the entire sample in 2001. This means that the panel effectively was turned into a rotating panel with full replacement in 2001: one series starting from 1994/95 to 2000/01 (30 provinces) and another from 2001/02 to 2007/08 (45 provinces). Furthermore, a closer look at the data revealed serious problems with the first series of the panel. In particular, the roster is not available for 1994/95 and 1995/96 have been wrongly merged (Himelein, 2009). Therefore, we use only the 2001/02-2007/08 panel to estimate equation (3).

Table 1.1: Composition of surveyed households

Year	Total of HHs	HHs re-interviewed the following year	HHs re-interviewed 1 year or more after	Attrition	New HHs
1996	4,535				4,535
1997	4,799	3,640	0	895	1,159
1998	5,057	4,305	102	596	854
1999	4,855	4,411	273	919	717
2000	4,801	4,199	477	1,133	1,079
2001	3,762	7	1	4,795	3,756
2002	3,807	3,325	4	441	486
2003	3,381	3,258	50	599	173
2004	3,970	2,458	332	1,255	1,844
2005	3,971	3,970	0	0	1
2006	3,916	3,431	182	722	667
2007	4,264	3,791	371	496	844

Source: Nistha and Josefina, World Bank, mimeo.

1.12 **The survey uses 2-stage village level sampling**. Villages are selected first according to their production potential (small land holdings high output vs. large land holding lower output). In the second stage, farm households are divided into two groups and selected based on a list of 17 variables such as land area for cereals, land area for other cash crops, number of household members, gender composition, number of household members in farming, etc.

Table 1.2: Households and parcel characteristics

	Households characteristics		Parcel characteristics		
	Male (%)	Age (years)	Plain/Plato	No anti-erosion scheme	Only cotton
2002	99.0	48.9	98.4	99.1	98.8
2003	99.6	42.6	98.6	99.3	99.7
2004	99.6	42.3	98.4	99.2	59.2
2005	98.7	48.9	97.9	99.4	65.7
2006	98.0	49.0	98.2	99.3	NA
2007	99.2	48.6	98.0	99.2	58.0

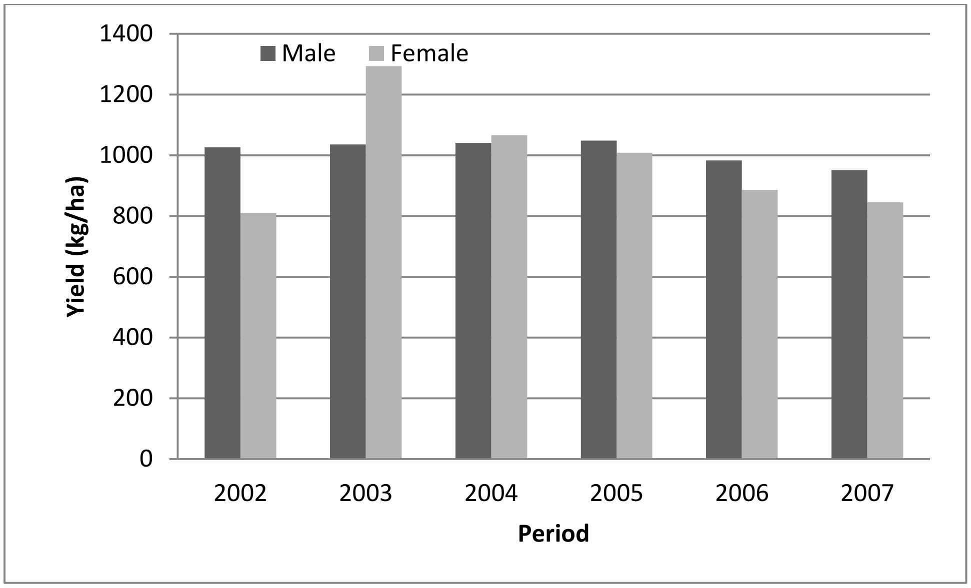
Source: Authors' computation.

1.13 **Table 1.2 shows that the majority of surveyed cotton growers were headed by males.** It is unclear whether this reflects the actual gender distribution of cotton growers in Burkina Faso or the way the sample was designed. The average age of cotton growers varies from 42 years in 2004 to 49 years old in 2006. The addition of 1,844 new households in 2004 does not seem to have disrupted the characteristics of surveyed farmers. However, given the implementation of the fairtrade program in 2004, which promotes fair trade standards including, but not limited to, equal representation of women and ensuring that women growers receive payments directly one would expect a significant increase in the number of female growers (FLO 2008, 2009).

1.14 **About 98 percent of cotton growers are farming in the plains/Plato. Moreover, the majority of farmers report not using any anti-erosion techniques.** This poses challenges for increasing yields in the future because use of marginal lands has increased environmental concerns since the newly introduced lands are typically located in environmentally sensitive areas where exposed soils are prone to erosion and degradation (Vitale et al., 2011, p. 1138). Table 1.2 also shows that in 2002 and 2003, the vast majority of farmers did not inter-crop cotton with other crops. However, the data we have shows that practice to have changed around 2004 as more growers appear to have switched to intercropping.

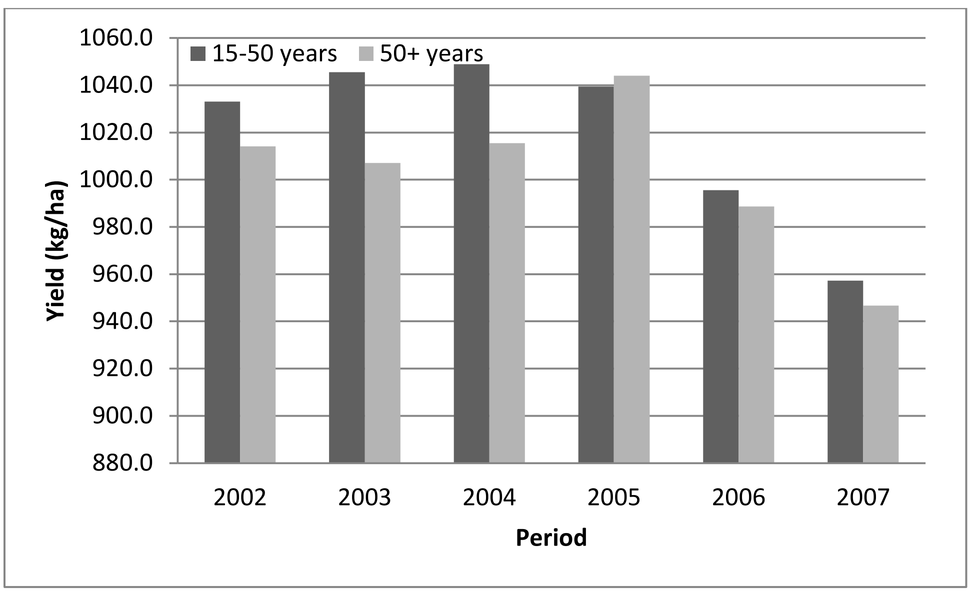
1.15 **Cotton yields have decreased by 1.4 percent on average over the 2002-2007 period: from 1024.1 kg/ha in 2002, the yield dropped to 952.3 kg/ha in 2007**. On average, males headed households were more productive than female headed households. According to Figure 1.2, males achieved 1016.9 kg/ha compared to 938.2 kg/ha for females. And this difference in yield is higher for males only in 2002, 2005, 2006 and 2007. In Uganda, Baffes (2008) report that males' cotton yields where 3-4 times that of females'. However, one must be cautious about drawing strong conclusions from this result because there might be possible over-representation of males among cotton farmers, as shown in Table 1.1, and the internal organization of households may not be able to reveal the true contribution of women to cotton production. Indeed in Burkina Faso and a number of countries in the Region, there are often common plots – where all adult members of the family contribute – and gender specific plots.

Figure 1.3: Cotton yield by gender



Source: Authors' computation.

Figure 1.4: Cotton yield by age groups

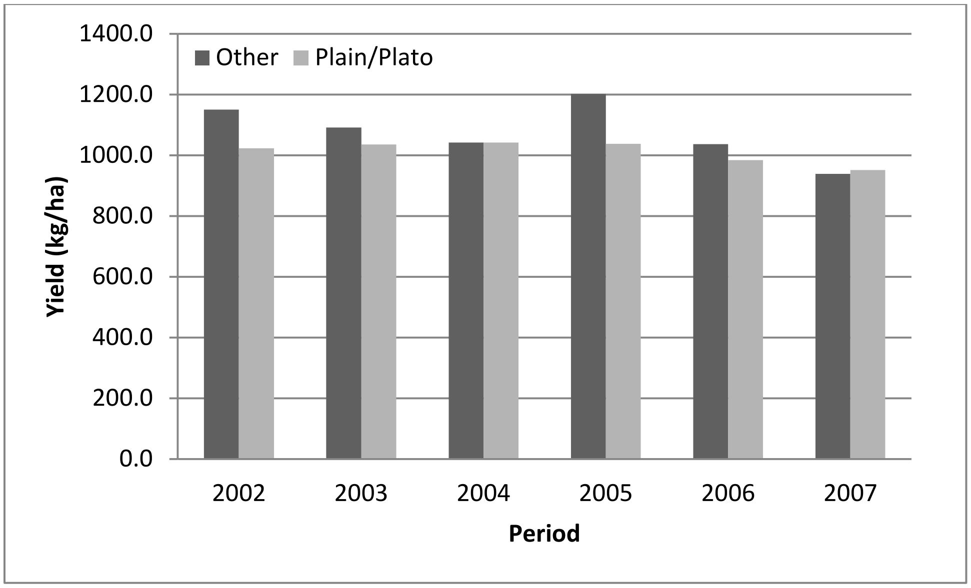


Source: Authors' computation.

1.16 **On average, cotton growers between 15 and 50 years old do better than their counterparts of 50 years or more; the first group achieved 1024.3 kg/ha compared to 1004.7 kg/ha for the second group.** However, this worth noting that the yield gap between the two groups is much smaller in the last three years compared to the first three years of 2002-2007 (Figure 1.3).

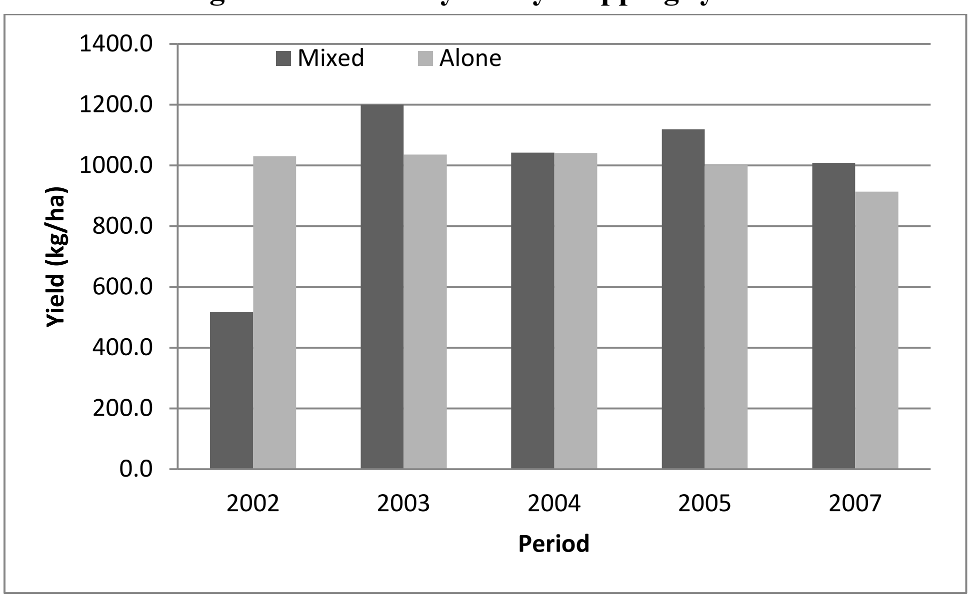
1.17 **Except in 2004 and 2007, cotton yield on areas other than plains is slightly higher than the one in plains or Plato (Figure 1.4)**. There seems to be a clear difference between yield under intercropping (mixed) and single system (Figure 1.5). On average, farmers produce 1053.8 kg/ha when they intercrop cotton with other crops compared to 1012.0 kg/ha when cotton is planted alone.

Figure 1.5: Cotton yield and parcel slope



Source: Authors' computation.

Figure 1.6: Cotton yield by cropping systems



Source: Authors' computation

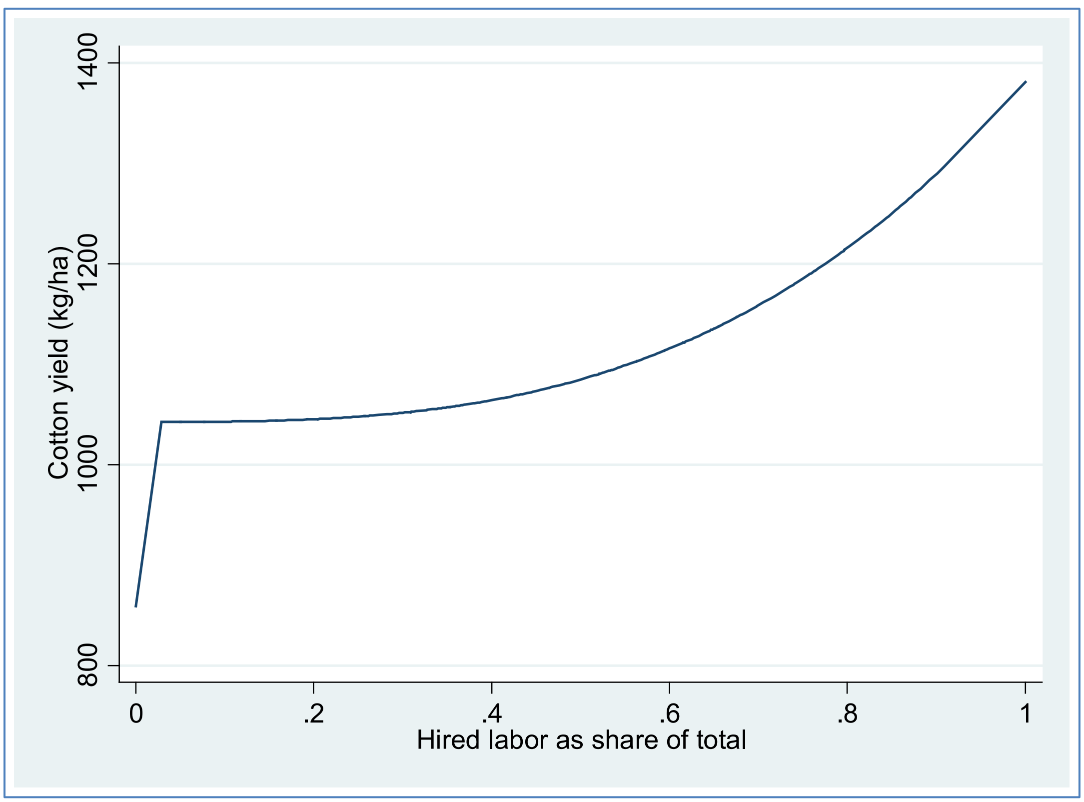
1.18 **Information on labor allocated to cotton production was collected only in the 2007/2008 round**. As expected, overall cotton labor force is dominated by family labor which accounts for 51.4 percent of total compared to 24.0 percent for loaned labor and 24.6 percent for hired labor (Table 1.3). However, family labor participation varies quite a lot across farming activities. It peaks during the sowing season (86.5 percent participation) but then declines when farm activity is devoted to crop management (56.9 percent participation) and harvesting (32.6 percent participation). We also find that cotton productivity increases with the share of hired labor (Figure 1.6). This is explained mostly by availability of hired labor for harvesting. The later is a labor intensive activity and timely availability of labor has the benefits of reducing production losses. As reported in Figure 1.7, male participation is more important in plowing season (86.0 percent) and crop management season (66.5 percent) than during the sowing season (45.1 percent) and harvesting season (46.7 percent).

Figure 1.7: Composition of labor force by farming activities (%)

	Plowing	Sowing	Crop management	Harvesting	All
Family	81.4	86.5	57.0	32.6	51.4
Loan	13.8	9.0	23.1	30.7	24.0
Hired	4.8	4.5	19.9	36.7	24.6
Total	100.0	100.0	100.0	100.0	100.0

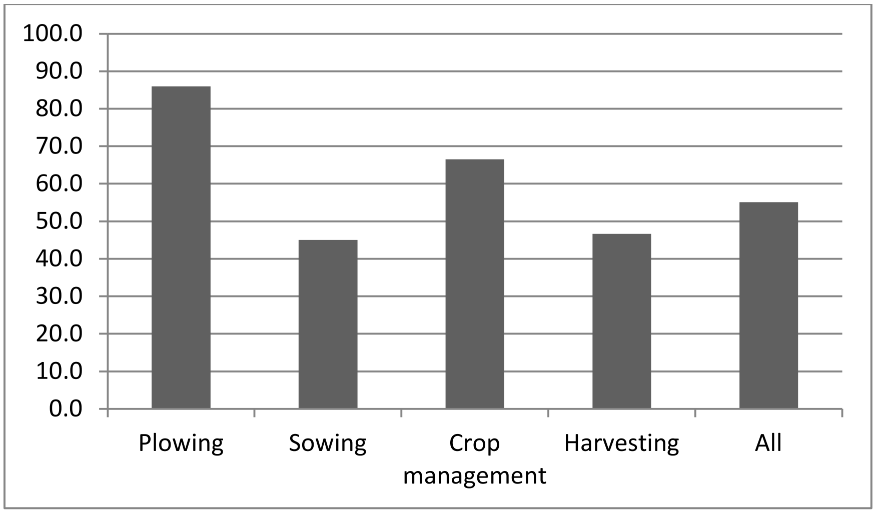
Source: Authors' computation

Figure 1.8: Cotton yield and share of hired labor



Source: Authors' computation

Figure 1.9: Share of males' labor in cotton activities (%)



Source: Authors' computation

1.19 **Nationally, cotton sector accounts for about 60 percent of Burkina exports revenue during the period of analysis**. In this study, we use the distribution of crop revenue for 2006 and 2007 to estimate the dependency rate as the ratio of cotton revenue to total crop revenue (Table 1.4). Our results suggest that the average dependency on cotton revenue is around 55-65 percent nationally but varies a great deal across regions. The most cotton dependent regions include Hauts-Bassins, and Mouhoun where the dependency rate is above 60 percent. If cotton revenue dependency is a reflection of the importance of cotton in the livelihood of farm households, Table 1.4 suggests that the most dramatic expansion of cotton happened in the East and South-West (Est and Sud-Ouest) Regions of the country. Meanwhile, there appears to be a major decline in the Center South (Centre Sud) Region.

Table 1.3: Cotton revenue as share of total household (cash) revenue (%)

	2006	2007
Centre	12.0	13.6
Nord	0.0	0.0
Centre Sud	52.0	34.7
Centre Ouest	47.0	48.6
Mouhoun	65.0	70.3
Est	35.1	50.9
Centre Est	24.9	21.8
Sahel	0.0	0.0
Centre Nord	2.0	3.3
Cascades	83.4	83.8
Hauts Bassins	77.1	78.9
Sud Ouest	33.3	54.7
Plateau central	9.2	8.2
Average	56.9	62.6

Source: Authors' computation.

1.20 **In the next section we present the results from the stochastic frontier function estimates. We estimate a model of yields and one for production**. Our main goal is to assess the determinants of cotton production. We capture technical change with a time dummy and the role played by accumulation of factors by the contribution of individual inputs. We also use a "policy" dummy to distinguish the post-2004 period, when cotton liberation began, from the period prior; however, the associated estimate was not significant.

E. ESTIMATION RESULTS

1.21 **As reported in Table1.5, land is by far the most dominant factor of production. Indeed, elasticity of cotton production with respect to land is about 1.20**. The observed positive and significant impact of land on cotton production can be explained by the constant increase in both the quantity of land allocated to cotton production and its share as a percentage of the total land. Since most of the cotton is expanding into what is considered marginal lands, the responsiveness of output to land expansion can come from two channels. One is the expansion of "virgin" land – land that has not been cultivated before. The second channel is the conversion of land that had been devoted to other crops into land for cotton. Which of these two channels is the most dominant is not something we can easily discern from the data.

Table 1.4: Stochastic Frontier results for panel (2002-2007)

	Dependent variable: cotton production (kg)				**Dependent variable: cotton yield (kg/ha)**	
	Without provinces effects		**With provinces effects**		**Without provinces effects**	
	Coefficient	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Land	**1.2086**	**0.0120**	**1.1905**	**0.0121**		
Fertilizer (kg)	**0.0238**	**0.0065**	**0.0170**	**0.0064**	**0.0313**	**0.0063**
Fertilizer squared	**0.0049**	**0.0012**	**0.0045**	**0.0012**	**-0.0049**	**0.0012**
Rainfall (mm)	**0.5626**	**0.0595**	**0.4047**	**0.0833**	**0.6173**	**0.0581**
Age of household head (years)	0.0042	0.0044	0.0049	0.0042	0.0052	0.0043
Age squared	0.0001	0.0000	0.0001	0.0000	-0.0001	0.0000
Gender of household head (1 if female, 0 if male)	0.0545	0.0928	0.0051	0.0893	-0.0174	0.0909
Slope (1 if plain/Plato, 0 otherwise)	0.0454	0.0672	0.0296	0.0659	-0.0322	0.0662
Anti-erosion scheme (1 if not, 0 otherwise)	0.0243	0.1063	0.0599	0.1060		
Time	**0.0345**	**0.0075**	**0.0404**	**0.0074**	*-0.0178*	*0.0072*
Intercept	**2.0870**	**0.5607**	**2.1561**	**0.7397**	**1.6529**	**0.5380**
sigma2	106.8	89.5	74.5	74.6	48.4	32.2
gamma	**0.9976**	**0.0020**	**0.9966**	**0.0034**	**0.9949**	**0.0034**
sigma_u2	106.5	89.5	74.3	74.6	48.2	32.2
sigma_v2	**0.2520**	**0.0065**	**0.2516**	**0.0065**	**0.2457**	**0.0064**
Observations	4107		4107		4107	
Log likelihood	-3699.4		-3484.2		-3627	
Wald chi2(10)	11565.2		15875.9		156	

Notes: Bold means significant at 1%, while italic means significant at 5%.

1.22 **Over the 2002-2007 period, cultivated land has indeed dramatically increased from 1811.3 ha in 2002 to 2994.7 ha in 2006 but decreased temporarily by 29.8 percent in 2007 (Table 1.6)**. Similarly, per capita land allocated to cotton production increased from 2.4 ha in 2002 to 3.3 ha in 2006, an increase of about 38 percent. According to Kaminski and Thomas (2009), Burkina Faso's dependence on cotton has grown since the early 1990s as a result of the implementation of institutional reforms, which have brought new land and producers to cotton production.

Table 1.5: Cultivated land (ha)

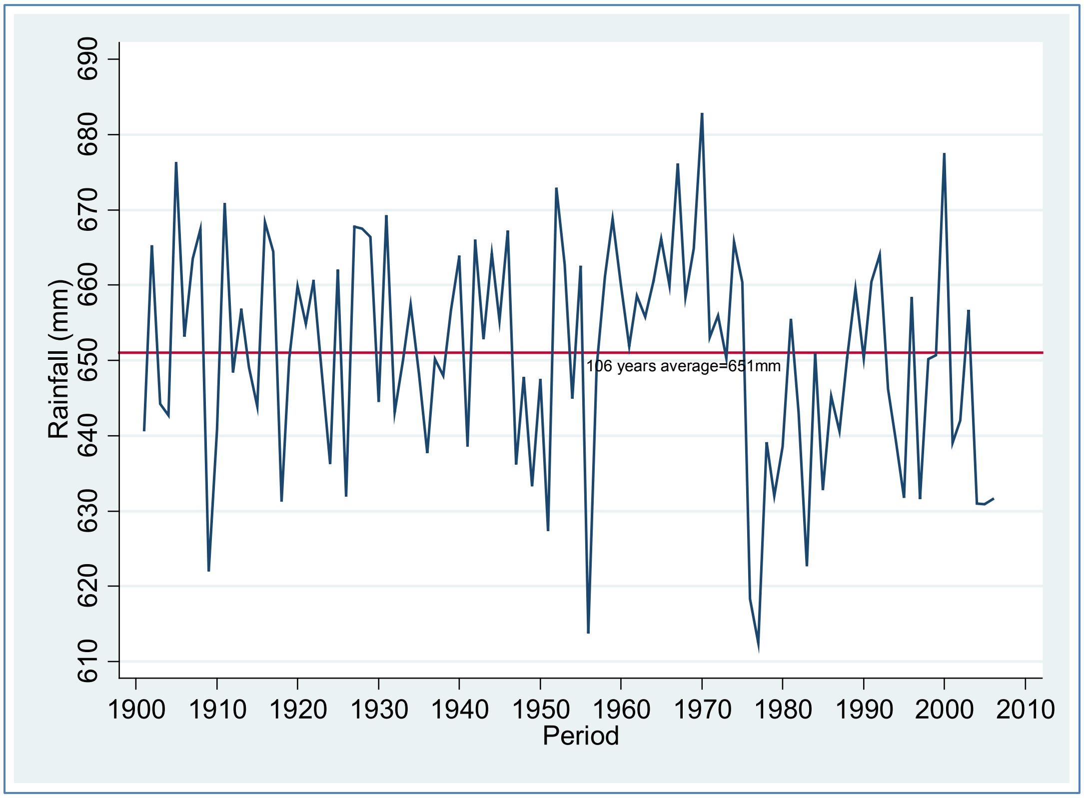
	Total	Per capita
2002	1811.3	2.4
2003	1722.7	2.5
2004	2354.6	2.4
2005	2661.6	2.6
2006	2994.7	3.3
2007	2101.8	2.6

Source: Authors' computation.

1.23 **No other input has nearly as much influence on production.** The marginal impact of fertilizer use on cotton production is positive and significant but the impact is small. This is because fertilizer use for cotton in Burkina is rather negligible, about 125 kg/ha over the 2002-2007. By comparison, a country like Brazil uses on average 335 kg/ha for cotton yield of 3051 kg/ha on average (FAO, 2004). Anecdotal evidence suggests that the low uptake of fertilizer use may be related to its price. For instance, in 2011 more than 2000 cotton growers threatened to boycott the 2011-12 season protesting against government increase of fertilizer price, unless the government lowered the price of fertilizers from US$34 to US$28 per bag. Lowering the price of fertilizer to the farmers' request would have cost the country an extra US$18 million (Gongo, 2011). That said, the use of fertilizer increases with availability of roads and rainfall which happen to be in limited supply in Burkina (Kaminski, 2011).

1.24 **As expected, rainfall has a significant impact on cotton production and yields.** Results in Table 1.2 suggest that a 10 percent increase in rainfall would increase cotton production by 5.6 percent. However, it will increase yields by 6.2 percent. As pointed out by Vitale et al. (2011), cotton production in Burkina Faso occurs primarily in the Sudanian and Sudano-Guinean agro-ecological zones. Both of those agro-ecological zones are able to support rain-fed cotton production, with average annual rainfall of 600–800 millimeters (mm) in the Sudanian zone and average annual rainfall of 800–1100 millimeters in the Sudano-Guinean zone. Unfortunately, from 1952 to 1984, Burkina suffered from a steady drop in rainfall from 814 mm to 483 mm (see Figure 1.8). Since 1970, the country was hit by five major drought episodes: 1970 - 1973, 1983 - 1984, 1991 - 1992, 1997 – 1998 and 2003 – 2004. Out of 106 years between 1901 and 2006, the rainfall has been below the yearly average of 615mm, 54 times! Hence, to sustain a viable cotton production system, which will have to involve an increase in yields, Burkina Faso desperately needs to reduce its reliance on rainfall for water, perhaps by introducing efficient irrigation systems or drought resistant cotton varieties.

Figure 1.10: Rainfall trend in Burkina



Source: Data from Jones and Harris (2008).

1.25 **Total Factor Productivity (TFP) is defined as the portion of output not explained by the amount of inputs used in production.** In this study, technical change is measured as the change in total output with respect to time. As reported in Table 1.7, cotton sector in Burkina has been experiencing negative TFP growth despite steady efficiency change. Indeed, the overall TFP trend is driven by negative technical change of 3.4 percent over the 2002-2007 period. This might have played a role in the introduction of Bt cotton in 2008 when about 125,000 ha of second-generation insect-protected biotech cotton (Bollgard II from Monsanto Co.) were planted for the first time in Africa. BGII is reported to have increased cotton yields by 18.2 percent over conventional cotton, which reached as high as 36.6 percent in one of the cotton production zones. Moreover, since the higher seed costs from adopting BGII were offset by equivalent savings in insecticide costs, cotton income increased by $61.88 per ha compared to conventional cotton (Vitale et al. 2010).

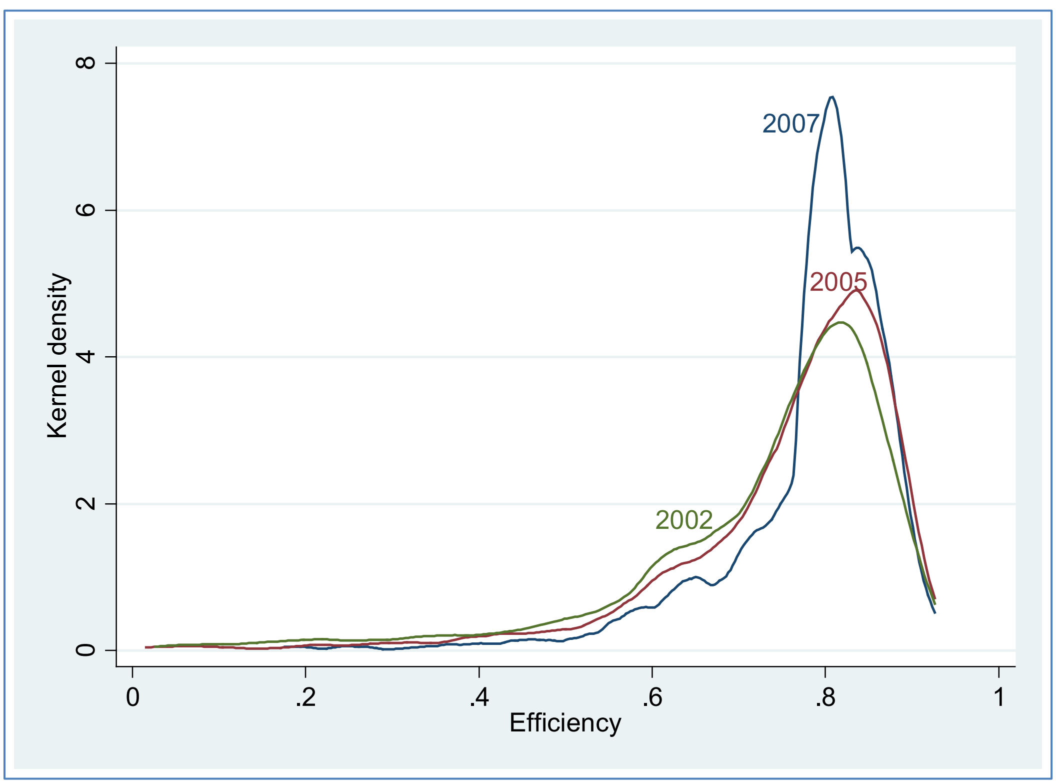
1.26 **For the cotton sector in Burkina Faso, our results suggest that over the 2002-2007 period, agricultural efficiency slightly increased on average from 0.729 in 2002 to 0.781 in 2007**. Efficiency change encompasses several meanings. A firm/farm is efficient if for a given technology and input levels it produces the highest (that is, optimal) output. Conversely, a firm is efficient if for a given technology and output levels, it uses optimal levels of inputs (Balk, 2001, p.160). Hence, efficiency depends on the quantity of inputs as well as the state of the technology being used. However, these average figures mask wider difference among farmers as shown in Figure 1.9 where later years exhibit efficiency distribution with an increasing share of high efficient cotton producers compared to year 2002. There is also a great deal of heterogeneity across provinces where efficiency estimates range from 0.057 in Oubritenga to 0.845 in Bazega (Figure 1.9). Our findings also suggest that provinces with higher efficiency tend to be more productive. Although limited, these efficiency gains may be linked to the trend of reforms implemented by the government since 1992. For example, economic activities including provision of cereal input credit, management assistance of cotton groups, and participation in quality grading, financial management, and price bargaining were progressively delegated from the government to the national cotton producers' union (UNPCB). In 2002-2006, new players including private input providers, regional private cotton companies (SOCOMA, FASOCOTON) – who participate in production, help organize farmers, secure access to inputs, take risks on behalf of farmers, purchase seed cotton from farmers, operate ginneries and market cotton lint products - and private transport companies were brought in (Kaminski et al. 2009). In addition, price-setting mechanism changed to better reflect world price levels.

Table 1.6: TFP decomposition

	TFP	TC	TE
2003	-3.2	-3.4	0.2
2004	-1.2	-3.4	2.3
2005	-2.4	-3.4	1.0
2006	-1.9	-3.4	1.5
2007	-1.6	-3.4	1.9

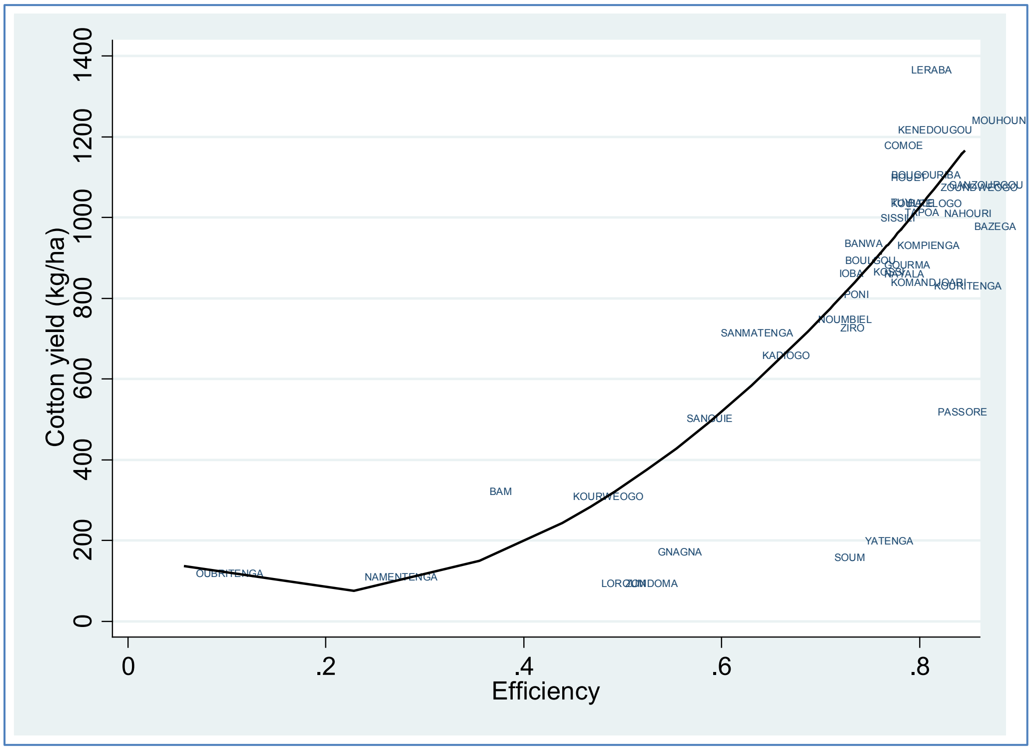
Source: Authors' computation.

Figure 1.11: Distribution of efficiency



Source: Authors' computation.

Figure 1.12: Efficiency and yield by provinces



Source: Authors' computation.

1.27 **In summary, our main result suggests that over 2002-2007 period, growth in cotton production[2] has been driven by land expansion**. As shown in Table 1.8, most of the growth in cotton production is explained by growth in land use. In fact only 21 percent of the overall growth is explained by variables other than land - such as farmer and plot characteristics but also labor which is not included in the estimation. This is the fraction of the decomposition in Table 1.8 that is labeled "other". By contrast, TFP which includes technical change is negative during the same time period. Of course, land expansion may have followed after the policy reforms that were enacted at the beginning of 2000s. In that sense, it can be said that policy reforms induced these changes in land usage. This hypothesis is proposed in Kaminski et al. (2009), which estimates that two-thirds of the threefold increase in production from 1996 to 2006 is explained by policy changes. In this paper, we could only estimate direct effect of input allocations, so cannot reject this hypothesis.

Table 1.7: Decomposition of cotton production growth over 2002-2007

Production growth	**Inputs**				**TFP**
	Land	**Fertilizer**	**Rainfall**	**Other[3]**	
+2.1	+3.3	-2.1	+1.4	+1.7	-2.1

Source: Authors' computation.

[2] See equation (4).
[3] Such as labor not included here.

F. CONCLUSION

1.28 **In this paper we show that except for a dip in 2007, cotton production in Burkina Faso has expanded rapidly since the 2000s**. This has made the country one of the largest producers of cotton in Africa. However, we also show that cotton production in the country continues to be dominated by non-modern techniques. For instance, fertilizer use is low and unproductive, partly because there is far too much reliance on rain water and recommended farming practices are not followed. The consequence has been little technical change, which is reflected in stagnant yields.

1.29 **The main policy challenge facing cotton production in Burkina is how to increase yields**. The production increases that have relied purely on factor accumulation, especially land, will not be sustainable in the medium to long term as land suitable for cotton production becomes exhausted and the marginal productivity of existing land declines. Therefore, to sustain production growth, Burkina Faso will need to modernize its cotton production technology. A promising start is the adoption of agricultural biotechnology. In 2008, Burkina Faso commercially released 125,000 hectares of Bt cotton. Field trials and producer surveys report that Bt cotton increased cotton yields and raised farmers' income per hectare. However, managing these modern techniques demand a number of innovations. First, some sufficient capacity for research and extension will be needed. Second, institutions for seed, fertilizer, soil fertility and water management will be necessary in order to disseminate knowledge on the complementarities of input use. Such institutions exist for seed and fertilizer, but there is not one for water since irrigation schemes are limited. For instance, although a significant potential of irrigable land is estimated to exist, irrigated agriculture accounts for only 9 percent of irrigable land, which represents 0.6 percent of total cultivated land. Reducing heavy dependence on rainfall is critical for improving yields because with rainfall comes volatility and inefficient input mix. One instrument to reduce rainfall related risk is to explore the possibility of weather-index insurance. Together with the producer floor price, such an instrument has the potential to provide predictable and less volatile income for cotton farmers. This in turn may propel them to adopt modern inputs. However, smoothing income for farmers should not be confused with increasing yields and productivity. In the context of Burkina Faso, this will certainly involve reducing dependence on rainfall and/or introducing drought resistant seeds.

1.30 Finally, managing the potential of Bt cotton will require credible institutions to enforce biosafety compliance (Vitale et al. 2011) and maintaining a transparent and attractive pricing regime.

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