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Burkina Faso
Determinants of Cereal Production
Stochastic Frontier Approach for Panel Data
A Policy Note 3b

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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
DES	Dietary Energy Supply
EBCVM	*Enquête Base sur la Condition des Vie des Ménages*
EICVM	*Enquête Intégrale sur les Condition de Vie des Ménages*
EP	*Enquête Prioritaire*
EPA	*Enquête Permanent Agricole*
FCFA	Franc CFA
FAO	Food and Agriculture Organization
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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1. Determinants of Cereal Production in Burkina Faso Stochastic Frontier Approach for Panel Data

A. CONTEXT

1.1 **In the last ten years, Burkina Faso economy experienced an average annual growth rate of about 5 percent, with a peak of 7.4 percent in 2005**. This growth bust is mainly driven by the performance in the agricultural sector, where growth averaged 5.2 percent over the past ten years. However, the dependence of agricultural sector to weather variability cannot guarantee a sustained growth trend.

1.2 **Agriculture in Burkina Faso is almost exclusively extensive, and is practiced mainly on family farms (about 800,000 farms), dominated by small farms.** The arable land is estimated at 9 million ha (approximately 30 percent of the total land area). Only 3.5 to 4 million hectares (one third) are actually cultivated annually. The main crops include cereals (sorghum, millet, maize, rice and fonio) which occupy nearly 88 percent of cultivated land every year; legumes and tubers which cover a very small area (about 2 percent); cash crops (cotton, sesame, groundnut, soybean and sugar cane) account for 9 percent of cultivated land; vegetables (mainly tomato, onion and green beans) and fruit (mainly mango).

1.3 **Only 24,000 ha of land are irrigated for an irrigable potential of 233,500 ha. Irrigated crops include rice, sugarcane and vegetables.** Market gardening is also practiced in irrigated areas and also in small individual gardens especially in suburban areas. In recent years, the country has been promoting irrigated maize (dry season) through small-scale irrigation.

1.4 **During the past decade, grain production grew at an average rate of 4.6 percent per year led by maize which experienced a steady growth of 10.7 percent on average annually and millet which grew by 5.9 percent**. Average cereal production was about 2.7 million tons during that period. Still, cotton remains the main cash and export crop of the country; it accounts for 2/3 of export earnings of the country.

1.5 **Sorghum, millet, and maize are the main cereals produced and consumed throughout the country.** The cereals share in total dietary energy consumption is around 73 percent (FAO, 2010). Sorghum and millet accounted for 26 percent and 22 percent, respectively, of the total dietary energy supply (DES) in 2005-07 (FAO-GIEWS database). On average in 2004-08 per capita consumption of sorghum was 83 kg/year, and that of millet was 62 kg/year. The self-sufficiency ratio of sorghum is 105 percent and 103 percent for millet. Bulk of rice is imported and mostly consumed in urban areas. Rice accounted for 6 percent of the total dietary energy supply (DES) in 2003-05. On average in 2004-08 per capita consumption (as food) of rice was 21 kg/yr. The self-sufficiency ratio of rice is about 24 percent (FAO-GIEWS database).

1.6 **The National Strategy for Food Security by 2015 aims to create favorable conditions for sustainable food security and inequality and poverty reduction in Burkina Faso**. Endorsing the guidelines of the World Summit on Food in Rome in 1996, the Government has set a target to reduce by 50 percent the number of people suffering from hunger and malnutrition

by 2015. The specific objectives of the strategy include i) increase the level of domestic food production; ii) strengthen the capacity of the market to improve people's access to food; iii) improve the economic conditions of the poor and vulnerable groups; iv) improve the prevention and management of cyclical food crises; and v) strengthen the capacities of stakeholders and promote good governance for food security.

1.7 **The main purpose if this paper is to analyze factors driving cereals production in Burkina.** More specifically, this study intends to generate research-based evidence to guide the design and implementation of strategies to improve the productivity of cereals production for poverty reduction and food security. To do so, we use farmers level panel data collected from 1994 to 2007.

1.8 **Our findings confirm that land is indeed the dominant driver of cereals production in Burkina.** Like overall agricultural production system in Burkina, cereals production is also rain-dependent. This should be a concern as the country's economic growth depends on agricultural sector, which itself remains highly dependent on climate variability. Finally, our results suggest that cereals production system in Burkina is characterized by significant provinces and time heterogeneity.

B. METHODOLOGY

1.9 We follow the methodology developed by Battese and Coelli (1995) and Kumbhakar and Lovell (2000) as described below. The production function is given as follows:

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

where $i = 1,..., N$, represents agricultural households, q_{it} is a production vector $(n \times 1)$ at time period *t*, x_{it} is the input vector $(1 \times k)$, β is the $(k \times 1)$ vector of parameters to be evaluated, t represents time trend and ε_{it} represents the efficiency of household *i*, with $0 < \varepsilon_{it} \leq 1$. If $\varepsilon_{it} = 1$, 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, $\upsilon_{it} \sim N^{+}(0, \sigma_{\upsilon}^{2})$.

In logarithmic form, equation (6) can be formulated as follows:

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

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

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

The growth rate of output into contribution from the growth of inputs versus productivity change is given by

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

where TFP is the Total Factor Productivity which TFP growth can be decomposed into technical change (TC) and technical efficiency (TE). Technical change is defined as the marginal change in output with respect to time trend

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

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

C. DATA DESCRIPTION

1.10 **The agricultural panel survey Enquête Permanent Agricole (EPA) is conducted by the Ministry of Agriculture**. The survey is administered to farm households since 1994, constituting two panels at the household level: from 1994/95 to 2000/01 (30 provinces) and from 2001/02 to 2007/08 (45 provinces). The variation in the number household across the years reflects attrition as well as the new households incorporated in the data set as shown in Table 1.1. Attrition rate varies between zero percent in 2005 and 100 percent in 2001. 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.

1.11 **The survey uses village level sampling in 2-stratus.** Villages are selected first according to their production potential (small land holdings high output vs. large land holding lower output) and some households' characteristics. In the second stage, farm HHs are selected based on a list of 17 variables such as land area for cereals, land area for other cash crops, number of HH members, gender composition, number of HH members farming, etc., and also dividing HHs in two groups (defined from those 17 variables).

1.12 **In this paper, we focus on main cereals (millet, maize, rice, fonio, and sorghum); as shown in Table 1.2, millet is the most important followed by maize and sorghum**. Millet and maize alone account for at least 80 percent of land allocated to cereals production.

Table 1.2: Share of cultivated land for main cereals (%)

	2002	2003	2004	2005	2006	2007
Millet	58.0	57.4	54.7	54.8	54.0	54.5
Maize	24.7	26.1	29.8	28.7	29.8	29.3
Rice	2.0	1.8	1.8	1.8	1.9	1.6
Fonio	0.3	0.3	0.5	0.5	0.3	0.7
Sorghum	15.0	14.4	13.2	14.2	13.9	14.0
All	100.0	100.0	100.0	100.0	100.0	100.0

Source: Authors' computation.

1.13 **More than 90 percent of surveyed cereals growers were headed by males (Table 1.3).** This is in sharp contrast with FAO reports indicating that women produce over 50 percent of all food grown worldwide (FAO, 2008a) and grow 80-90 percent of the food in Sub-Saharan Africa (FAO, 2008b). However, according to González et al. (2011), in Burkina Faso women cultivate cereals, but do not make any decisions. Our results show that average age of cereals growers is around 49 years old varying from 44 to 51 years old.

Table 1.3: Households and parcel characteristics

	Households characteristics		Parcel characteristics		
	Male (%)	Age (years)	Plain/Plato	No anti-erosion scheme	Only cereals
2002	94.8	50.9	96.3	98.0	94.6
2003	95.5	43.7	97.0	97.2	95.6
2004	95.4	43.6	96.9	97.5	75.3
2005	94.0	50.9	96.6	98.1	79.1
2006	93.0	51.0	97.1	97.9	NA
2007	93.4	51.2	97.1	97.5	77.6

Source: Authors' computation.

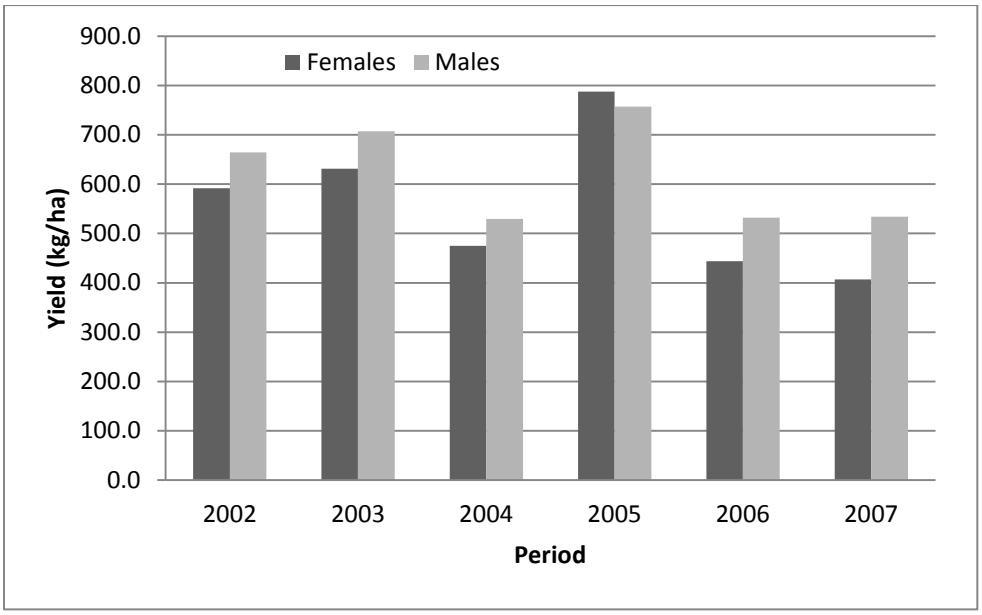
1.14 **On average, 97 percent of cereals growers are farming in the plains/Plato. More than 97 percent of cereals farmers report not using any anti-erosion techniques**. Anti-erosion techniques include the construction of small dikes of stones (rock bunds) to slow down run-off water flows, improve water infiltration in the soil and to reduce loss of top soil through wind and water erosion (Rochette, 1989). Vitale et al. (2011) report that the 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. In 2002 and 2003, the vast majority of farmers practiced mono-cropping; however, since 2004 at least 20% of growers are practicing intercropping.

1.15 **The trend of cereals yield in Burkina has been quite erratic over the 2002-2007 period**; from 660.4 kg/ha in 2002, the yield increased to 703.9 kg/ha in 2003 before dropping to 526.4 kg/ha in 2007. On average, males headed households were more productive than female headed households; males produced 615.8 kg/ha against 541.4 kg/ha for females. It is only in 2005 that females farmers achieved higher yield than their males counterparts, 787.8 kg/ha against 757.1 kg/ha (Figure 1.2). The observed low yield among females may be explained by the fact that in general women work on land of poor quality, often land that has been left fallow and produces a lower yield (González et al., 2011). In addition, women do not have the physical strength needed to use soil-conservation techniques which means that their land suffers more damage when there are floods or heavy rain.

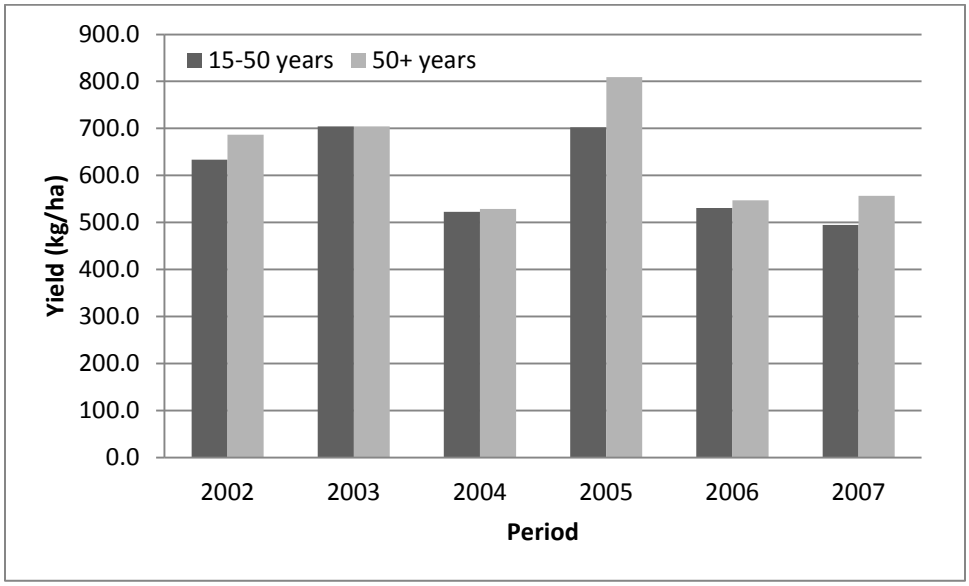
1.16 **On average, cereals growers over 50 years perform better than their counterparts of age between 15 and 50 years**; the first group produced 630.3 kg/ha compared to 591.3 kg/ha for the second group. However, it is worth noting that the yield gap between the two groups is significant only in 2005 (Figure 1.3).

Figure 1.1: Cereals yield by gender



Source: Authors' computation.

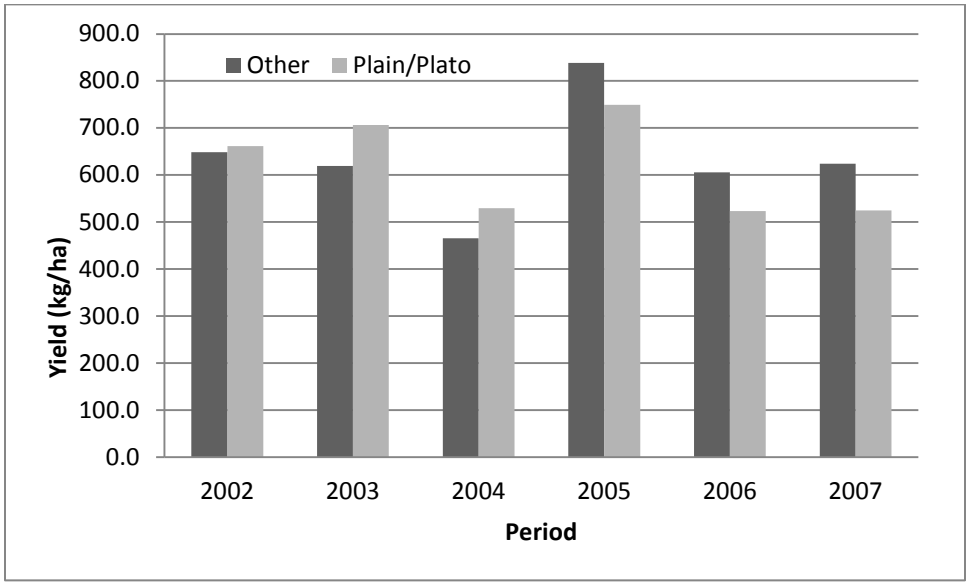
Figure 1.2: Cereals yield by age groups



Source: Authors' computation

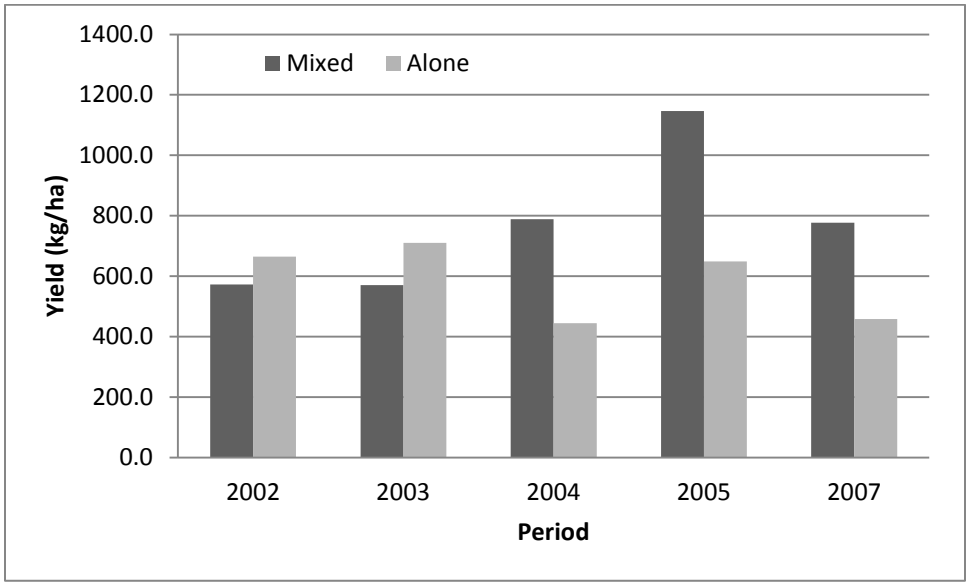
1.17 **From 2002 to 2004, cereals yield produced in plains is higher than the one in other areas (Figure 1.4)**; however, from 2005 to 2007 the trend shifted in favor of cereals cultivated in areas other than plains and plato. With respect to cropping system, there is a significant difference in cereals yield between intercropping (mixed) and mono-culture systems (Figure 1.5); on average, farmers produced 857.5 kg/ha when they mix cereals with other crops compared to 588.2 kg/ha when cotton is planted alone. Osman et al. (2011) argue that intercropping of pearl millet with cowpea can improve crop production without increasing input levels.

Figure 1.3: Cereals yield and parcel slope



Source: Authors' computation.

Figure 1.4: Cereals yield by cropping systems



Source: Authors' computation.

1.18 **Only the 2007/2008 survey rounds collected information on labor.** As expected, like cotton (see Table 1.4b) cereals labor force is also dominated by family labor which accounts for 77.0 percent of total compared to 17.0 percent for loaned labor and 6.0 percent for hired labor (Tables 4a). Unlike cotton, the dominance of family labor is observed in all activities, reaching 91.8 percent during the sowing season but reduced to 69.4 percent (crop management) and 73.5 percent (harvesting). We also found that cereals yield increases with the shares of hired and loaned labor (Figure 1.6) but decreases with the share of family labor. The share of hired labor in cereals production is much lower than in cotton production; cotton being an export crop requires probably more qualified labor from the market. As expected (Figure 1.7), males' participation in cereals production is more important in plowing season (80.9 percent) and crop management season (59.6 percent) but less so during the sowing season (39.9 percent) and harvesting season (46.6 percent).

Figure 1.5a: Composition of labor force by cereals farming activities (%)

	Plowing	Sowing	Crop management	Harvesting	All
Family	77.6	91.8	69.4	73.5	77.0
Loan	17.6	6.8	22.4	18.7	17.0
Hired	4.8	1.4	8.2	7.8	6.0
Total	100.0	100.0	100.0	100.0	100.0

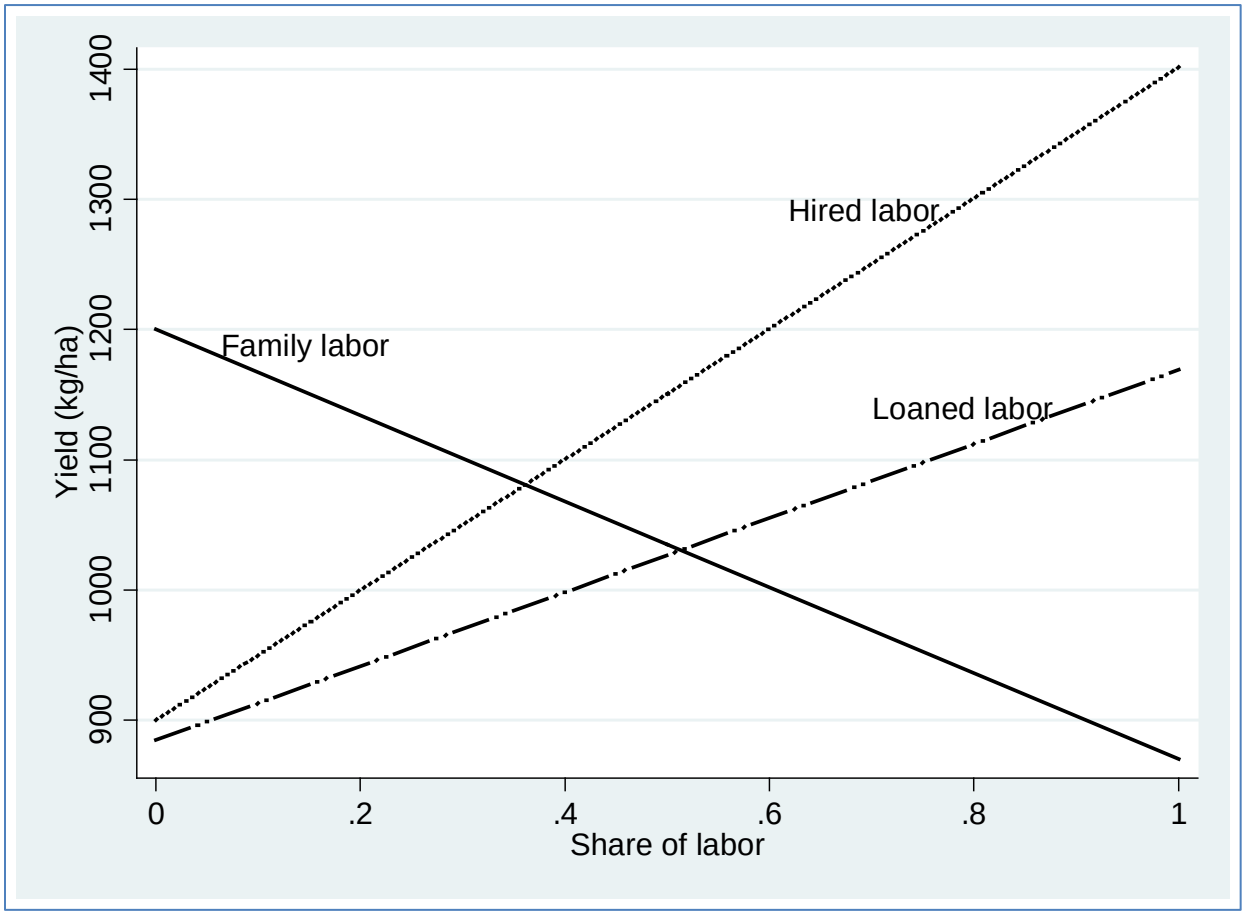
Source: Authors' computation.

Figure 1.6b: Composition of labor force by cotton 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

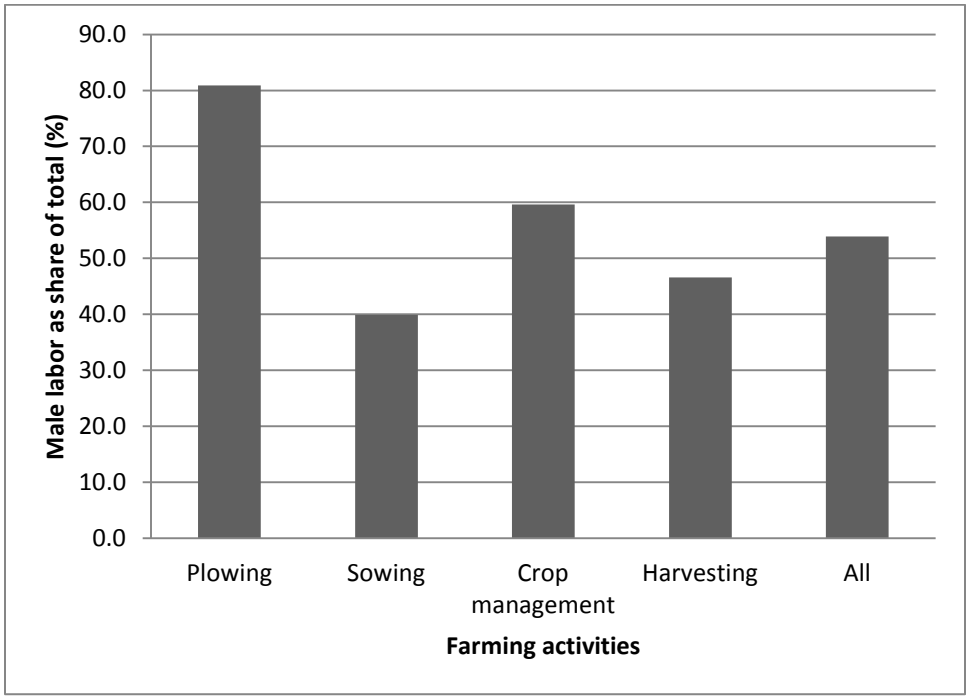
Source: Authors' computation.

Figure 1.7: Cereals yield and share of hired labor



Source: Author's computation

Figure 1.8: Share of males' labor in cereals activities (%)



Source: Author's computation

1.19 **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 and overall crop revenue (Table 1.5)**. Our results suggest that the average dependency on cereals revenue is around 20 percent compared to about 60 percent for cotton. The dependence on cereals revenue varies across regions; the most dependent regions include Centre, Sahel and Sud Ouest.

Table 1.4: Cereals revenue as share of total household revenue (%)

	2006	2007
Centre	44.2	44.4
Nord	10.1	8.7
Centre Sud	20.4	28.8
Centre Ouest	25.7	25.8
Mouhoun	14.8	18.3
Est	34.0	26.8
Centre Est	29.4	36.5
Sahel	40.8	51.5
Centre Nord	19.9	24.3
Cascades	8.0	8.5
Hauts Bassins	16.9	13.2
Sud Ouest	43.8	24.7
Plateau central	34.8	34.1
Average	20.8	18.9

Source: Authors' computation

D. ESTIMATION RESULTS

1.20 **In Table 1.7 we present three different specifications:** i) without fixed effects (I); ii) with provinces fixed effects (II); and iii) with provinces and time fixed effects (III). The results suggest significant provinces and time heterogeneity as shown by the Likelihood-ratio test reported in Table 1.6. For example, estimates for fertilizer and rainfall change dramatically from the model with no fixed effects to the one with both provinces and time fixed effects. As a result, the discussion below will focus on the specification with provinces and time fixed effects.

Table 1.5: Likelihood-ratio test

	LR Chi^2	Degree of freedom	p-value
(I) against (II)	713.8	42	0.00
(II) against (III)	987.8	84	0.00
(I) against (III)	273.9	42	0.00

Source: Authors' computation.

1.21 **As reported in Table 1.6a, land appears as the dominant driver of cereals production in Burkina; elasticity of cereals production with respect to land is estimated at 1.61**. However land elasticity is reduced to 1.19 with provinces fixed effects and 1.20 without fixed effects when accounting for labor (see Table 1.6b). Impact of land on cereals production is mainly the result of increase in total land allocated to cereals production. Over the 2002-2007 period, total cultivated land has indeed increased steadily from 8526.8 ha in 2003 to 11283.4 ha in 2007 (Table 1.8). However, neither the average land holding nor the share of cereals land over total land has significantly changed; average land holding remains around 2 ha and the share of cereals land around 43 percent of total cultivated land.

Table 1.6a: Frontier results[1] for panel (2002-2007)

	No fixed effects		With provinces fixed effects		With provinces and time fixed effects	
Dependent variable=cereals production (kg)	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Land	1.5489[a]	0.0131	1.6123[a]	0.0135	1.6123[a]	0.0134
Fertilizer (kg)	0.1054[a]	0.0117	0.0626[a]	0.0122	0.0511[a]	0.0125
Fertilizer squared	-0.0258[a]	0.0033	-0.0172[a]	0.0034	-0.0127[a]	0.0034
Rainfall (mm)	0.6231[a]	0.0528	0.0719	0.0839	0.1736[c]	0.0966
Age of household head (years)	0.0042	0.0053	0.0067	0.0052	0.0064	0.0052
Age squared	0.0000	0.0001	-0.0001	0.0000	-0.0001	0.0000
Gender of household head (1 if female, 0 if male)	-0.0532	0.0641	-0.0404	0.0632	-0.0494	0.0630
Slope (1 if plain/Plato, 0 otherwise)	0.2492[a]	0.0752	0.1137	0.0744	0.1292[c]	0.0746
Time	-0.1226[a]	0.0093	-0.1063[a]	0.0093	-0.1553[a]	0.0551
Intercept	0.9962[b]	0.5020	5.9775[a]	0.7480	5.2098[a]	0.8504
σ^2	50.89[a]	16.60	71.37[b]	32.54	483.57	576.44
γ	0.95[a]	0.02	0.97[a]	0.02	0.99[a]	0.01
σ_u^2	48.39[a]	16.60	68.89[b]	32.54	481.14	576.44
σ_v^2	2.50[a]	0.03	2.48[a]	0.03	2.43[a]	0.03
Observations	17527		17527		17527	
Log likelihood	-34190.0		-33833.0		-33696.1	
Wald chi2(51)	(51) 16091.1		(51) 18191.4		(93) 18628.4	

Notes: a,b and c means significant at 1%, 5% and 10% respectively; S.E.=standard error

[1] Production and inputs variables are all in log form

Table 1.7b: Frontier results with labor (2007)

	No fixed effects		With provinces fixed effects	
Dependent variable=cereals production (kg)	**Coefficient**	**S.E.**	**Coefficient**	**S.E.**
Land	1.1998[a]	0.0176	1.1850[a]	0.0179
Family labor (female)	-0.0058	0.0084	-0.0178[b]	0.0079
Family labor (male)	0.0113	0.0109	0.0390[a]	0.0096
Loaned labor (female)	0.0290[a]	0.0073	0.0087	0.0071
Loaned labor (male)	-0.0049	0.0066	-0.0012	0.0063
Hired labor (female)	0.0220[b]	0.0107	0.0268[a]	0.0102
Hired labor (male)	0.0150[c]	0.0078	0.0039	0.0072
Fertilizer (kg)	0.0044	0.0077	0.0139[c]	0.0076
Fertilizer squared	0.0027	0.0027	-0.0042[c]	0.0026
Age of household head (years)	-0.0018	0.0050	-0.0011	0.0045
Age squared	0.0000	0.0000	0.0000	0.0000
Gender of household head (1 if female, 0 if male)	-0.1527[b]	0.0598	0.0108	0.0575
Slope (1 if plain/Plato, 0 otherwise)	0.1009[b]	0.0506	0.0075	0.0485
Anti-erosion scheme (1 if not, 0 otherwise)	-0.1191[b]	0.0548	-0.0645	0.0509
Intercept	7.6330[a]	0.1503	7.1524[a]	0.1584
sigma_v	0.2559[a]	0.0108	0.2067[a]	0.0101
sigma_u	1.7819[a]	0.0232	1.7132[a]	0.0219
sigma2	3.2407[a]	0.0818	2.9778[a]	0.0742
lambda	6.9635[a]	0.0274	8.2889[a]	0.0257
Observations	3809		3809	
Log likelihood	-5337		-5116	
Wald chi2(DF)	7489 (14)		8928 (58)	

Table 1.8: Cereals land

	Average land holding	Share of land allocated to cereals	Total land
2002	2.5	43.2	9755.9
2003	2.5	43.4	8526.8
2004	2.2	41.1	8616.6
2005	2.1	42.0	9242.2
2006	2.4	44.5	10694.5
2007	2.6	42.5	11283.4
All	2.4	42.8	58119.3

Source: Authors' computation.

1.22 **The marginal impact of fertilizer use on cereals production is significant but non-linear; this reflects the fact that a minimum level of fertilizer use is required before observing increase in cereals production as a result of increased fertilizer use**. Fertilizer use for cereals over 2002-2007 period was erratic and rather negligible; 0.03 kg/ha in 2002, 98.2 kg/ha in 2005, and 27.3 kg/ha in 2007. In Brazil, Lopes et al. (2003) report average fertilizer use of 83 kg/ha for rice and 119 kg/ha for maize. Many factors can explain limited fertilizer use in cereals production in Burkina, including high price, road infrastructure and weather instability.

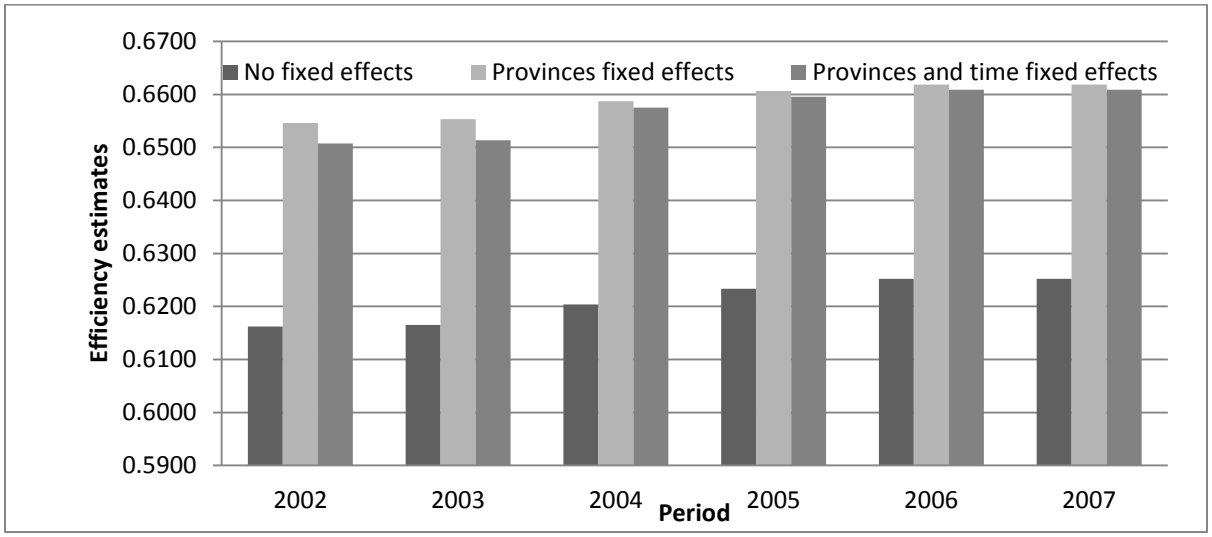
1.23 **Like overall agricultural production system in Burkina, cereals production is also rain-dependent**. Indeed, a ten percent increase in rainfall is expected to increase cereals production by 17.4 percent. Stroosnijder and Rheenen (2001) contend that crop performance in the Sahel is limited by both water and nutrient availability. The country's economic growth depends on agricultural sector, which itself remains highly dependent on climate variability. Since 1970, the country suffered from five major drought episodes; as a result, poor rainy seasons led to a slowdown in economic growth, whereas good rainfall caused acceleration in economic growth.

1.24 **The estimation results for 2007[2] (he only period for which labor data are available) confirm that different types of labor have different impacts on production**. Indeed, using estimates with provinces fixed effects, only hire d female and family male labor are positive and significant (Table 1.6b). The marginal productivity of family female labor is significant but negative.

1.25 **As mentioned earlier, cereals production system in Burkina is characterized by significant provinces and time heterogeneity**. Results reported in Figure 1.8 suggest that accounting for provinces and time fixed effects almost double the estimates of efficiency. Therefore, only results from specification with provinces and time fixed effects. As reported in Table 1.9, cereals production in Burkina experienced negative TFP growth driven by negative technical change. On the other hand, efficiency estimates increased on average from 0.651 in 2002 to 0.661 in 2007; the complete distribution of efficiency estimates is reported in Figure 1.9. On average, efficiency estimates range from 0.594 in the province of Yagha to 0.733 in Bazega.

[2] The only year for which labor data are available

Figure 1.9: Effects of provinces and time fixed effects



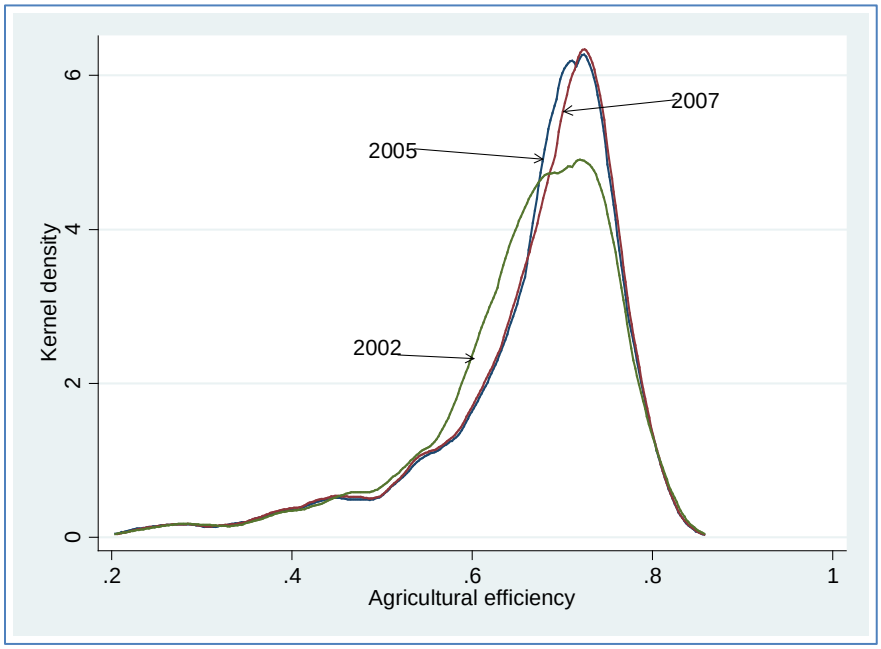
Source: Authors' computation.

Table 1.9: TFP decomposition

	TFP	TC	TE
2003	-15.4	-15.5	0.1
2004	-14.6	-15.5	0.9
2005	-15.2	-15.5	0.3
2006	-15.3	-15.5	0.2
2007	-15.5	-15.5	0.0

Source: Authors' computation.

Figure 1.10: Distribution of efficiency



Source: Author's computation.

E. CONCLUDING REMARKS

1.26 **Cereals production in Burkina mirrors the characteristics of the overall agricultural sector**; it has been growing through land expansion and is highly rain-dependent. As a result, yield growth has been erratic following weather instability. Our results also suggest that productivity as measured by yield is negatively correlated with the share of family labor. This should be a concern as the labor force involved in cereals production is dominated by family labor which accounts for 77.0 percent of total compared to 17.0 percent for loaned labor and 6.0 percent for hired labor. Cereals sector is affected by negative TFP growth as a result of negative technical change and insignificant efficiency change. Differences in production function across provinces are significant suggesting a geographical targeting approach in addressing the sector's weaknesses.

1.27 **To strengthen cereals production system and probably the whole agricultural sector in Burkina Faso, the government needs to**: i) reverse fertility loss and resource degradation, ii) improve management of water resources while expanding access to both small- and large-scale irrigation; and iii) improve agricultural research with clear strategy on the dissemination and adoption of drought-resistant technology.

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