TSE WP working paper series

09-008

Research Group: *Environmental Economics and Natural Resources*

January, 2009

Commodity Reform and Extensive Production Growth: Evidence from Burkinabè Cotton Farmers

JONATHAN KAMINSKI AND ALBAN THOMAS

Ecole d'économie de Toulouse (TSE) - Manufacture des Tabacs
Aile Jean-Jacques Laffont - 21, allée de Brienne - 31000 TOULOUSE
Tél : +33 (0) 5 61 12 85 89 - Fax : +33 (0) 5 61 12 86 37 - **www.TSE-fr.eu** - contact@TSE-fr.eu

Toulouse School of Economics

Commodity Reform and Extensive Production Growth: Evidence from Burkinabè cotton farmers*

Jonathan Kaminski

Department of Agricultural Economics and Management, the Hebrew University of Jerusalem, P.O. Box 12, Rehovot 76100, Israel. Email kaminski.jonathan@gmail.com

Alban Thomas

Toulouse School of Economics (INRA, LERNA) and IDEI, 21, allée de Brienne, 31000 Toulouse, France. Email thomas@toulouse.inra.fr

Abstract

Over the 1996-2006 period, Burkina Faso has experienced a reform of its cotton sector, and has become the largest African cotton producer and exporter. The cotton "boom" consisted of a rapid expansion of cotton areas through the growth of land shares allocated to cotton (and new producers), together with an overall increase in total cultivated land. In this paper, we present an empirical framework to determine the contribution of total farmland changes in the increase of land dedicated to cotton, where both processes are represented by ordered endogenous variables. The empirical framework is supported by a conceptual model which takes into account the specific institutional features of the Burkina Faso rural cotton economy and builds upon data collected in rural Burkina Faso in March 2006.. From measurable indicators of farmer behavior and variables that measure farmer statements for the reasons of this behavior, we are able to identify both direct and indirect effects of the cotton reform on the extensive growth of cotton seed production. They are namely mechanization and technical assistance, labor intensification, enhanced managerial abilities (learning by doing and better environment for farmers), production incentives arising from the new local organizations of producers, guarantees and confidence stemming from the sector and an easier access to agricultural inputs. They all can be attributed to better institutional arrangements between producers and stakeholders which have been established during the reform.

JEL Codes: N57, 013, O33, Q15, Q18

Keywords: Parastatal, Burkina Faso, Cotton, Land use, Land allocation, Commodity reform.

* We are grateful to participants of the CSAE Annual Conference on "Economic Development in Africa" and the discussant of this paper, Andrew Zeitlin. We are indebted to Sylvie Lambert and participants of PSE Lunch Seminar, as well as to Stéphane Straub for their useful advices and comments. We warmly thank ARQADE and Jean-Paul Azam for financial support and advices. We are also grateful to Kimséyinga Savadogo for having hosted us in Burkina Faso in spring 2006 and having helped us to lead the survey in cotton areas.

Commodity Reform and Extensive Production Growth: Evidence from Burkinabè Cotton Farmers

Over the last two decades in Sub-Saharan Africa, commodity market reforms have challenged many policymakers and called into question many economists. Based on the premises that liberalized commodity markets would have increased farmer crop profitability, which, in turn, would have stimulated farm investment and rural development, the dismantlement of former official boards and other parastatals–through the release of government controls- was expected to raise both commodity output and supply chain performance. Notwithstanding, significant increases in farm productivity have not been generally observed and the reform programs have exhibited mixed results. According to Jayne et al. (1997), these premises often failed to account for the institutional features specific to each country and each commodity. Major institutional constraints[1] have limited the scope of newly generated benefits achievable through the elimination of former policy constraints to private investment incentives.

In contrast to a successful top-down implementation, the development of the cotton economy in West Africa has been supported by millions of smallholders and by a "peasant cotton revolution" (Bassett, 2001). This has been induced by a rapid evolution of farming techniques and producers' social organizations. Often quoted as one of the few success stories of agricultural development in the region, the cotton sector is now one of the economic growth leading factors (see Azam and Djimtoingar, 2004) and the dominant cash crop for farmers in the Sahel. It also represents one of the major strategies in poverty reduction for rural zones –as the livelihood of numerous smallholders- and the major source of cash inflows and export earnings for those countries (Goreux, 2003).

In West Africa, the cotton sector was organized until recently in a very integrated fashion, with parastatals involved in input provision, ginning, and marketing. Poor economic performance was associated with huge financial insolvencies, poorly-managed boards, and high tax burden bore by producers. The reform process –where it has been undertaken- has been supported by changes in economic and social institutions from local to national scales. This has applied to the organization of markets (input sales, cotton purchases, ginning, marketing, input and rural credits) within a process of partial to full privatization of the industry and to the institutional arrangements between producers, investors and governments.

The liberalization process has introduced a coordination problem since cotton production requires a complex governance system where a number of key public goods must be provided: delivery of inputs, credit provision and recovery[2], research and development, and quality grading. When new stakeholders enter the commodity chain, their benefits could be increased when market coordination is well achieved, yet not engaging into those activities. This classic collective action problem has been shown to be linked to the degree of competition in the African cotton sectors by Poulton et al. (2004). This is the so-called coordination competition trade-off.

The effects of these reforms have been mixed (see Goreux, 2003), even if prices paid to producers have increased relative to world prices (see Baffes, 2004). Whenever unregulated liberalization occurred, cotton production plunged drastically after a short-term boom, caused by the increase in investments and new entrants. The collapse in production often occurred because of strong coordination failures among stakeholders, resulting in low level of public good provision and input credit recovery rates. This has substantially prevented farmers to benefit from better price incentives to invest in farm productivity. Regulatory schemes within a new institutional design have been established to cope with the coordination issue, as in Benin or in Zambia. New institutional arrangements[3] have been promoted to foster market coordination and to set up viable input credit schemes.

In Burkina Faso, the reform consisted of a new institutional design before privatizing the industry, including establishments of a partnership between ginneries and producers and new local organizations of cotton growers. The resulting large increase in repayment rates of input credit and more bargaining power for producers (Kaminski, 2007) led to more production incentives for cotton production, attracting new farmers and new land to cotton seed production. Burkina Faso has become the largest African cotton producer -production has been multiplied threefold between 2001 and 2006- partly because of the cotton reform but also because of the Ivorian Crisis in 2002 that resulted in a massive inflow of Burkinabè farmers, formerly settled in Côte d'Ivoire. However, this labor force has been oriented towards the cotton sector because of new incentives generated by the sector's reform. Because of its focus on institutional innovations, a closer examination at the Burkina Faso experience would be helpful to bring some insights in the controversy about commodity market reforms.

In this paper, we present an empirical study of the determinants of cotton growth in Burkina Faso, which is supported by a survey of producers conducted in March 2006, in representative cotton areas. We are particularly interested in the underlying mechanisms, at the farmer scale, which can explain the genuine pattern of extensive growth of cotton production. We aim to determine to what extent the growth of cotton areas can be attributed to the reform of the cotton sector, and to identify producers' incentives and changes in production capacities that might be involved in this growth. To this end, we estimate the joint probability of changes in land allocated to cotton and in total cultivated land under several econometric specifications. The models employed to estimate this joint probability include a bivariate ordered Probit with endogeneous regressors and a single-equation binary Probit. Comparing the performance of these competing models and undertaking specification checks allows us to explore the robustness of our estimation results.

The remainder of this paper is as follows. Section 2 is a review of the cotton reform in Burkina Faso with some discussion supported by interviews of officials, stakeholders, and national data. Section 3 presents the empirical strategy that we follow in this paper, including a conceptual framework for land allocation and land use, data description, and the estimation strategy. Section 4 discusses the main results.

The cotton reform in Burkina Faso

After the independence of Burkina Faso in 1960, the parastatal firm SOFITEX[4] held a monopsony in cotton seed, and a monopoly in input provision and distribution, input credit, ginning and marketing cotton. Production was organized with groups of village producers, the GVs[5], where group lending schemes established. Research and extension services were provided by the government, in addition to some public goods supplied by SOFITEX such as rural road maintenance, education, and transportation of cotton seed. Prices were posted by the SOFITEX every three years for the purchase of cotton seed, the sale of agricultural inputs and the credit interest rate. As in many countries in French-speaking West Africa, the share of world price given to producers remained low because of explicit or implicit taxation from SOFITEX and poor management performances. The system was performing well until the 1990s because of top-quality agronomic research -with the participation of the former French cotton company, the CFDT- providing seeds and chemical inputs adapted to local conditions and a good coordination between village groups, banks and SOFITEX. Unfortunately, an increasing number of weaknesses put forward the idea that there was a need for reforming the cotton sector. Large deficits were experienced by SOFITEX, with a decrease in the repayment rates of input credit from GVs and with increasing scopes of opportunities in rent-seeking activities and corruption among parastatal's agents and GVs leaders[6]. As a result, SOFITEX experienced difficulties in paying producers and providing them with inputs.

Before the privatization of SOFITEX, some key institutional changes have been undertaken. Producers have gained significant bargaining power in the management of the sector, and new local institutions for cotton growers have allowed the implementation of new attractive outgrower schemes. The former joint-liability system of GVs matched cotton to non-cotton growers from the same villages for their input needs but the input cost was deducted from the value of cotton sales. In large groups, lack of peer monitoring within heterogeneous groups of farmers led to opportunistic behavior and less incentives for cotton production. The first step of the reform consisted in replacing GVs by GPCs[7], the new organizations of producers which were designed for cotton growers. Since 1996 in GPCs, producers are free to create their own group, to accept or reject new members, so that matching by affinities and self-selection are the core mechanisms of these new institutions. This design has allowed for better peer monitoring abilities and resulted in more cooperative behavior with more flexibility in group formation. Repayment rates have increased up to 95% and these organizations have continuously attracted new producers when they became operational after 2000.

The second step of the reform was the partial privatization of SOFITEX in 1999, when government transferred half of its capital shares to UNPCB[8], the new national union of cotton growers and the partial withdrawal of the government from the industry. Research and extension services are now held by SOFITEX and cotton unions. Then, a professional agreement was established between SOFITEX, banks, UNPCB and the national agronomic research institute. Producers were involved in management and decisions on pricing, funds for research and extension services, input provision, management of input credit and so on. Cotton unions were in charge of the provision of cereal inputs instead of SOFITEX while the latter focused on the delivery and credit for cotton inputs.

The third step of the reform began in 2002, with the entry of new investors in the ginning market. The goal was to attract new capital in the sector without changing the market organization of the sector. Indeed, the monopsonistic system was maintained with the definition of "concession areas" of purchasing cotton seed for each ginning firm, and SOFITEX retaining the major production area in the West. The Center of Burkina Faso was awarded to SOCOMA[9] and the East to FASOCOTON[10]. These two new firms were included into the professional partnership with SOFITEX, producers, government and banks. Today, prices are reported and decided upon within this partnership agreement as many other collective decisions. Input credit is supplied by SOFITEX only for cotton inputs and by UNPCB for cereal inputs. The last step of the reform was to set up a new pricing mechanism. Prices are now posted every year, based on forecasts of the world price and are associated with a more transparent "smoothing" fund[11], administered by the inter-professional partnership.

According to national agricultural data[12], cotton seed production had grown steadily until early 1990s up to 200,000 tons, due to the joint effect of a rise in productivity -improvement in the quality of inputs and seeds- and in cotton areas[13]. Because of the difficulties and the huge accumulated arrears faced by SOFITEX in the 1990s, there were bottlenecks to provide inputs to cotton growers and to pay them early after the harvest of cotton seed. As a result, production decreased in the 1990s until the currency devaluation[14] of 1994. This allowed for a significant increase in the competitiveness of the cotton sector and in the payments for cotton growers but with an increase in imported input prices. However, the SOFITEX deficits were not solved and worsened due to low repayment performances of the GVs.

After GVs were replaced by GPCs in 1996, the production started to increase again only after 1999 when input credit repayment rates became workable. This result was obtained because of the progressive implementation of new monitoring schemes (for input credit), more credible sanctions against defaulters as well as more flexible operation (self selection, free association of members). These elements have led to new and better incentives as analyzed in Kaminski (2007). The beginning of the production increase in 1999 is also the result of the privatization of SOFITEX with the entry of producers in its capital and the emergence of a strong integrated union of cotton growers. The management of the ginning firm has been improved and the rise of bargaining powers for producers has allowed increasing prices of purchasing cotton seed whereas world price of cotton declined. SOFITEX met new supports from the banks to contract with new farmers and supply them with inputs, sustaining the beginning of the cotton "boom". The entry of new investors in 2003 brought new funds for the cotton sector, therefore participating to the [15]. The partnership between ginning firms having local monopolies and a strong integrated cotton union is significant in the successful implementation of the reform supported by collective decisions and cooperative behavior. There has been a marked empowerment of producer unions allowed by the timing and the design of the reform. They have benefited from the reform, taking up a growing number of responsibilities thanks to the emergence of their political and bargaining power (World Bank, 2004).

For all involved stakeholders and for officials, the necessary condition to the reform success was the financial streamlining of the sector with better designed and performing credit schemes. The institutional shift from the GVs to the GPCs, and the new monitoring system set up by the inter-professional partnership between producers and ginners have been the crucial determinants of the higher credit repayment rates of the last crop campaigns. Privatization and liberalization have improved information access for producers and strengthened the inter-professional partnership. Some degree of confidence has emerged for producers with respect to cotton companies even though many contractual problems such as measurement errors, arbitrary quality classifications and corruption remain. With reduced or inexistent deficits and a sustainable credit scheme, banks have raised their commitments towards cotton companies, leading to more credit allowances for a growing number of producers[16]. This has also allowed producers to better access cereal inputs, so the cotton reform has also been beneficial to grain production and food security concerns.

Research is funded by the three companies and the cotton unions, and discussed within the inter-professional agreement. Contributions by government have declined substantially. For many executives of the sector, the reform has not been associated with a better concern for those "critical" functions. With the withdrawal of the government from the industry, funding research and extension services has become more difficult with the declining cotton prices. Considered as commons, the delivery of these services can be jeopardized by the privatization process that may raise the scope of coordination failures. Supporting these activities is a key issue for the young inter-professional association. The withdrawal of the government has also led GPCs to become involved in local public goods provision. Cotton revenues were sometimes reinvested by the government in public goods. But for now, only the largest and the best managed groups can afford to subsidize local educational or health programs.

Explaining the cotton "boom" requires accounting for exogenous shocks outside the reform process. The devaluation of the CFA Franc was responsible for the price-competitiveness of Burkinabè cotton until late 1990s and the Ivorian crisis in 2002 led hundreds of thousands of people to return to Burkina Faso and, in particular, to the traditional cotton area in the Southwest. These two exogenous shocks can account for part of the production growth trend but the cotton reform appears as the decisive factor. First, the price transmission mechanisms from the cotton world market to producers were weak, because of a high –both implicit and explicit- tax burden imposed by SOFITEX. Moreover, the production actually decreased again at the end of the nineties. The devaluation acted as a one-shot shock on export prices of cotton, and cannot explain the steady increase of producers' prices after 1999. Second, the Ivorian crisis has been shown to be responsible to an increase of 10 % of the rural labor force in cotton areas (Savadogo and Sakurai, 2007) after 2002. Everything being equal, this would have led for over-estimating the impact of the reform of 10 % more after 2002 (exogenous effect). However, other covariant effects must be taken into account, such as the internalization of the shock by rural households in their income risk-diversification strategy (endogenous effect). The lack of remittances brought by formerly expatriate Burkinabè farmers could also have influenced households to increase their cotton production in order to derive more cash incomes. But this would have been supported by the production incentives generated by the reform. Hence, we can only conjecture that the Ivorian Crisis turned into an amplification effect of the reform on national cotton production.

Comparing the Burkina Faso experience to its neighboring countries also provides elements of counterfactuals. Malian cotton economy looks like the one of Burkina Faso, except that cotton unions have a stronger political influence and that a political *status quo* has prevailed until now. Conditions for cotton growers in Mali have not significantly changed during the Burkinabè reform, even when world prices deteriorated. The pattern of production has remained stagnating after 2000, except during cotton strikes when government tried to reduce producers' price and very recently, because of more costly inputs. In Benin, cotton sector has been fully liberalized from 1992 with difficulties to establish adequate institutions. After a short-term positive effect on production, the production started to decrease rapidly after 2002 due to several coordination failures and the collapse of the input credit schemes. These are other arguments to support the reform as a decisive factor of extensive production growth in Burkina Faso.

[Figure 1 here]

The reform has not led to more intensive use of chemical inputs: pesticides and fertilizers; this fact is confirmed by national agricultural census and surveys (DGPSA[17], INSD[18]). The cotton growth has mostly relied on area extension caused by a rapid process of mechanization in cotton regions and more labor allocated to this crop (see figure 1). The latter effect can be explained by the rise in land shares allocated to cotton, demographic growth and migration to cotton zones. In fact, the rise in land shares allocated to cotton in agricultural systems often occurs in a significant way for new or recent producers (both resident and migrants)[19], which partly explained the overall increasing pattern of land use in favor of cotton. For some experts, price was not influential in land allocation choices made by farmers[20]. So, cotton areas have grown substantially because of more confidence for cotton growers in the sector and more –or less constrained- access to inputs. The private sector has been encouraged to build ginneries and provide services to farmers in regions where the parastatal company was not operating effectively, thus expanding the cotton producing area.

Average crop yield has been stagnating around 1.05 ton of cotton seed per Ha over the reform period. Though it can be attributed to limited soil fertility and limited potential of the seed varieties, the yield variability is even more important among producers. National data (DGPSA for plot data) show that cotton yields have improved on the best soils, with an important learning-by-doing effect but that new producers cultivate cotton on marginal lands sometimes with under-applications of inputs. However, average input use by unit of land has not risen, and individual increase in cotton yield has to be associated to a better long-term management of soil fertility (e.g. more manure applications), and an improved planning of mineral fertilizer and pesticide applications. Unfortunately, soil fertility is not sufficiently taken into account by farmers because of a lack of land tenure security and human capital, according to technical agents. The positive trend of individual crop productivity is outweighed by the entry of less productive farmers and lands. So, only extensive growth factors explain aggregated cotton production: the number of producers, crop allocation choices, and mechanization.

The empirical framework

To analyze the determinants of patterns in cotton areas, i.e., patterns in land use and land allocation among rural households, we firstly present the key specific institutional features in the environment of farmers in Burkina Faso. We then turn to a conceptual model of land use accounting for those specificities, and discuss further implications, before moving to the estimation strategy.

Institutional features for land cultivation and land use in Burkina Faso

In West Africa, not receiving land is socially unacceptable and many indigenous land tenure systems enable redistributing land. In Burkina Faso, there is no market for land, and land is more viewed as a social obligation than a material good. According to Stamm (1994), land rights are partially communal and partially individual, but cannot be considered neither a private, a public, nor a common good. Though it is almost impossible to sell or lease land, land can be obtainable through inheritance (in the restricted lineage), clearing of bush, gift, borrowing and temporary lending. The first three means of land access lead to secure rights of usage, and the last ones provide the so-called unsecured rights. As times goes, these rights can be converted in more secured ones. This is the typical way to access land for migrants. Temporary letting is awarded by traditional village authorities or specific land chieftaincies who can also take the decision upon land gifts or long-term letting. New village settlers have a ‘land tutor’ who directly interacts with the village chieftaincy and land owners. If the owner does not want to borrow the unused land, then the village chief is forced to find arable land for the migrant household.

Several arguments in the literature can be invoked regarding the inefficiencies of such a land tenure system, because of a problem of misallocation of land among households and capital, with a limited scope of productivity gains. However, empirical evidence shows that land rights –as interpreted and perceived by the local population- do not matter much in the allocation of factors and land investment (Sawadogo and Stamm, 2000) among households, because local peasants, including women, do not feel insecure about their usage rights. This story is different from the one of Udry and Goldstein (2008) where tenure insecurity is linked to less land investment (fallowing) for less politically-connected villagers and women. In contrast, allocation inefficiency is still important within households (Udry, 1996) because land and input accesses for women are determined through their husband decision.

Yet, Southwest Burkina Faso has been subject to high demographic pressure on land with population growth and migrants. Gray and Kevane (2001) showed that land scarcity has resulted in more land rights uncertainty and lower soil quality. Farmers have intensified their farming systems and adopted more conservation techniques as a strategy to secure their land rights and improve soil quality, but independently from their land status. However, it is not independent of the ethnic origin and farmers from migrant ethnic groups are willing to invest more in soil quality, other things being equal. This process has social costs since villagers who cannot access inputs such as fertilizers or manure are gradually left out the process of land allocation. Claims over land from non-resident ethnic group members have led to less fertile soils and new migrants are sometimes denied access to land. Hence, ethnic origin matters in the evolution of households' cultivated land, in addition to other social and political considerations.

Access to inputs –mostly fertilizers and pesticides- was managed by the GVs before the cotton reform, and has been undertaken by the GPCs once they have been established. While the former GV system helped influential farmers in the village access inputs independently from land allocation, the GPC system has allowed smaller free-adhesion groups formed by better connected individuals to gain access to inputs according to their experience and their land use pattern (cotton is the only cash income source to repay input credit). Accessing inputs does not depend anymore on social status nor on ethnic origin[21] but on the overall management of the GPC. Migrants may have to join existing groups before creating their own, so they may be constrained in input access but this is only related to experience in cotton growing and to the length of residence in the village. Hence, ethnic origin does not matter for input access, and therefore for land allocation. However, the latter is constrained by the former. We will take into account these features when specifying the conceptual model below.

Decisions about land use for rural Sahelian households are often modeled by lexicographic preferences according to a prior income goal and a secondary food security goal (see for instance, Abdoulaye and Sanders, 2006). Because some markets are missing (De Janvry et al., 1991) such as food or labor –and, in our case, input credit-, then production decisions are not separable from consumption ones in a household model representation. Let us now represent the problem of agricultural income maximization with risk-averse farmers before discussing the issue of lexicographic preferences and missing markets.

A conceptual model of land use under institutional constraints

Consider a household *h* allocating farm land among *K* crops, *i=1,2,…,K*. Each crop is associated with a farmer-specific technology, represented by the following profit level per unit of land:

$$\Pi_k^h = \pi_k^h(x_k) - c_k^h l_k^h, \qquad , k=1,2,\ldots,K, \tag{1}$$

where $\pi_k^h(\bullet)$ is random and concave, $x_k = (x_{k1}, x_{k2}, \ldots, x_{kJ})$ is a vector of *J* variable inputs, and $c_k^h l_k^h$ is the (non random) unit cost of cultivating land with crop k[22], assumed to be linear in land share l_k^h. With this specification, profit is separable in variable and land costs, and the randomness of profit appears only through the profit component associated with variable costs, π_k^h.

Given total arable land L^h, the problem of the household is to determine the optimal levels of inputs x_{kj} , *k=1,…, K ; j=1,…, J*, and land shares l_k , *k=1,…,K*. We specify a mean-variance utility function of profit, such that the farmer solves:

$$\begin{aligned} \underset{l_k, x_{kj}}{Max}\, V^h(l_k, x_k) &= L^h\ E\sum_{k=1}^{K} l_k^h \Pi_k^h - \gamma \operatorname{var}\left(L^h \sum_{k=1}^{K} l_k^h \Pi_k^h \right) \\ &= L^h \sum_{k=1}^{K}\left[l_k E\pi_k^h(x_k) - c_k^h \left(l_k^h\right)^2 \right] - \left(L^h\right)^2 \gamma \operatorname{var}\left(\sum_{k=1}^{K}\left[l_k \pi_k^h(x_k) - c_k^h \left(l_k^h\right)^2 \right] \right) \end{aligned} \tag{2}$$

such that $\sum_k l_k \leq 1$,

where *γ* is a measure of relative risk aversion taking values on [0,1]. At the optimum, the constraint in (2) is binding and first-order conditions can be written explicitly for crop *k, k=1, 2, …, K*:

$$l_k^{h*} = \frac{1 + \dfrac{1}{2L^h} \displaystyle\sum_{i=1}^{K} \frac{E\pi_k^h(x_k) - E\pi_i^h(x_i)}{c_i^h + \gamma\sigma_i^h(x_i)^2}}{\displaystyle\sum_{i=1}^{K} \frac{c_k^h + \gamma\sigma_k^h(x_k)^2}{c_i^h + \gamma\sigma_i^h(x_i)^2}} \quad \text{and} \quad \frac{\partial E\pi_k^h(x_k)}{\partial x_{kj}} = \gamma L^h l_k^* \frac{\partial \sigma_k^h(x_k)^2}{\partial x_{kj}}, \tag{3}$$

where $\sigma_k^h(.)^2$ is the variance of π_k^h. These expressions show that optimal land use is sensitive to risk-profitability profiles of all crops, according to household specific technologies and input use, which in turn depend on technology, output and input prices, risk aversion and the effect of input use on crop profit variability. Partial differentiation of (3) reveals that land use and input allocation are positively correlated, that is, everything else being equal, the bigger the land share, the more input applied on the crop. Note that relative profitability among crops matters less for land use when the total cultivated land increases, whereas input use increases if we assume that input use reduces profit variability. This is because the total amount of land increases each crop's total profit variability. If cultivated land is very large, then optimal land use is only significantly affected by relative land cost and risk profiles of each crop. The latter is influenced by information access, price variability, marketing opportunities and risk, and technical knowledge. Learning processes –whether learning-by-doing or from others- influence the latter through interaction with technical assistants, the degree of social capital and neighboring effects, and own experience (Besley and Case, 1994; Conley and Udry 2004). This can also play on the pattern of land extension when shifting from traditional to animal-drawn farming.

These optimal solutions are obtained when there are no missing markets. However, if the local food or labor market is of limited scope or not well integrated into regional markets, if the input credit market is not developed, these solutions are not achievable. A lexicographic specification would basically involve that households target an income goal $\overline{V^h}$ and then a food security goal that can be written as a function of land share dedicated to food production. Once the income goal is achieved, the household tries to reach its food security one but possibly does not maximize income. Food self-sufficiency allocation of crops can be optimal (Fafchamps, 1992; Jayne, 1994). If the income goal is only achieved when the food security one is not, then the household allocates land and inputs so as to move closer to the latter. Note that cultivable land and input access may be constrained or rationed by the social mechanisms described above and by interlinked agreements with cotton firms.

Because land and input access are constrained, each household has a specific food security goal according to its food needs, which can be expressed as a specific land share $l^h_{food}(L^h, x^h_{food}, x^h)$ where x^h is the vector of total applied inputs on all crops, and x^h_{food} is the one for food crops. All these matter since total input availability is constrained by land use and input allocation within GPCs and total cultivable land enable households to meet their food requirements. With restricted input and land, the household problem becomes $\underset{l_k, x_{kj}}{Max}\, V^h(l_k, x_k)$ such that

$$V^h(l_k, x_k) \geq \overline{V^h} \succ l^h_{food} \geq \overline{l^h_{food}}(L^h, x^h_{food}, x^h), x^h \leq \overline{x^h}, x^h_{food} \leq \overline{x^h_{food}}(l_k), L^h \leq \overline{L^h}\,. \quad (4)$$

Obviously, the food security goal is endogenous since it depends on expected agricultural income unless there is no food market at all. Then we obtain the following solutions:

$$\forall k, l_k^h = l_k^{h*} \text{ if } V^h(l_k^{h*}, x_k^h) \geq \overline{V^h} \text{ and } l_{food}^{h*} \geq \overline{l_{food}^h}(L^h, x_{food}^h, x^h) \quad (5)$$

$$l_{food}^h = \overline{l_{food}^h}(L^h, x_{food}^h, x^h) \text{ if } V^h(l_k^h, \overline{l_{food}}, x_k^h) \geq \overline{V^h} \text{ and } l_{food}^{h*} < \overline{l_{food}^h}(L^h, x_{food}^h, x^h) \quad (6)$$

$$l_{food}^h = l_{food}^h(\overline{V^h}) \leq \overline{l_{food}^h}(L^h, x_{food}^h, x^h) \text{ if } V^h(l_k^h, \overline{l_{food}}, x_k^h) < \overline{V^h} \text{ and } l_{food}^{h*} < \overline{l_{food}^h}(L^h, x_{food}^h, x^h)$$

(7)

Thus, land use is not only affected by available cropping land because of risk aversion and risk-diversification opportunities, but also because of food security reasons, land and input restrictions. Decisions about land use and land cultivation are not sequential, so the above insights support the idea that land use and allocation patterns should be jointly estimated such as simultaneous and endogenous processes.

Let us define two vectors X^h and Y^h, which are respectively vectors of all crops characteristics and household ones. The first one is composed by crop prices and price variability profiles, production risk, and cost components. The other one accounts for households' crop technologies, human and farm capital, risk aversion, labor force, social status, cotton experience, ethnic background, and off-farm opportunities. For estimation purposes, we make a first-order approximation of the difference in land use among village's households:

$$l_k^h(x_k^h, X^h, Y^h, L^h, \overline{V^h}, \overline{l_{food}^h}) - l_k^h(\overline{x_k}, \overline{X}, \overline{Y}, \overline{L}, \overline{V}, \overline{l_{food}}) \approx D_k^{'} \Delta W_k^h, \quad (8)$$

where bars indicate averages of village characteristics, D_k is a vector of partial derivatives of l_k with respect to characteristics, and ΔW_k^h is a vector of in-differences household characteristics such as

$$\Delta W_k^h = [x_k^h - \overline{x_k}, X^h - \overline{X}, Y^h - \overline{Y}, L^h - \overline{L}, \overline{V^h} - \overline{V}, \overline{l_{food}^h} - \overline{l_{food}}].$$

Since input access and use, income and food security goals depend upon land access, crop and household-specific characteristics, we can rewrite (8) with endogenous cultivated land and land use:

$$\begin{cases} l_k^h = a_0 + \alpha_k X^h + \beta_k Y^h + \gamma_k L^h + \lambda_k^v + \varepsilon_k^h \\ L^h = a_1 + AX^h + BY^h + C_k l_k^h + \eta^v + e^h \end{cases}, \quad (9)$$

where a_0 and a_1 are between-village averages and the regressors are both direct and indirect – through input use and access, food security and income goals- effects (partial derivatives) of variation in characteristics on cultivated land and land use. λ^v and η^v are village fixed-effects that explain between-village differences when everything is controlled for: soil characteristics, market connectedness, social capital, and so on. Note that the two error terms may be correlated, that is why a joint estimation is desirable. We are interested in the variation of land use and cultivated land patterns during the reform. To this end, we propose the following time-in-difference simultaneous model:

$$\begin{cases} \Delta l_k^h = b_0 + \alpha_k \Delta X^h + \beta_k \Delta Y^h + \gamma_k \Delta L^h + \Delta\lambda_k^v + \mu_k^h \\ \Delta L^h = b_1 + A\Delta X^h + B\Delta Y^h + C_k \Delta l_k^h + \Delta\eta^v + u^h \end{cases}, \qquad (10)$$

where *Δ(.)* is the in-difference operator between 1996 and 2006, assuming constant regressors except for village effects[23]. An identification condition of the model is that one element of the vectors of characteristics should be present in one of the two equations and not in the other[24]. Exogeneity would be tested under the following null hypothesis: $\gamma_k = C_k = 0$.

The data

In March 2006, we interviewed 300 households of cotton producers in the South and Southwest of Burkina Faso. We have focused on these regions because they belong to seven provinces that produce 45% of total national cotton production. They have been heterogeneous in their production dynamics over the reform period with a different historical background[25]. Then, the cumulative production dynamics of these regions have followed the same pattern as the national production[26].

From this area, five zones of close ethnological and linguistic characteristics were chosen with four villages -two important and two of secondary one- selected in each. Farmers' names were collected from updated lists of all GPCs of the village and classified into strata according to their cotton areas of the past crop season. Then, some households -16 in large villages, 14 in smaller ones- were randomly chosen in each stratum, proportionally to the size of the stratum. Villages were very heterogeneous in size, ethnic composition, as well as in the number and the experience of cotton growers between and within the five zones. Only households involved in cotton production, even in a marginal one, were interviewed. Indeed, our empirical strategy aims at explaining why cotton growers have increased their cotton areas. Some farmers might have abandoned cotton production and we should have tried to understand why, as well. However, according to national statistics, these farmers are few and very hard to be taken a census within villages of cotton growers. Thus, our study overestimates the increase in cotton areas but thus selection bias is small. Our first concern remains to identify the channels through which land use patterns and land cultivation have been modified and to get an idea about the size of effects. The selection issue is not relevant.

The questionnaire was designed with retrospective questions about the evolution of agricultural systems and economic decisions within each household over the 1996-2006 period. These variables were added to basic variables informing living standards, those are housing, education, health, consumption, credit, savings, crops, cattle. In addition to measurable indicators, households were asked about the reasons and the determinants of their choices and of the evolution of their decisions during the reform, concerning agricultural management. The availability of both measurable indicators of farmer behavior and variables that measure farmer statements for the reasons of this behavior enables us to empirically study a dynamic process (increase in cotton areas) with cross-sectional data. Description and information about the main variables are displayed in the appendix (tables 1, 2, 3). Because retrospective questions are inherently linked to measurement errors and recall problems, we use ordered variables to measure the increase in total farmland and in land shares dedicated to cotton.

Estimation strategy

Based on the insights from the conceptual model (10), these two components of the growth of cotton areas need to be somehow disentangled. Our dependent variables are discrete and ordered according to the level of increase or decrease in total cultivated land and land shares allocated to cotton per each household. They are estimated simultaneously by a bivariate Probit model. Let *i, i=1,2, ..., N* denote the (producer) individual's index and consider the general simultaneous-equation model:

$$\begin{cases} y_{1i}^{*} = \delta_1 + x_{1i}\beta_1 + u_{1i}, \\ y_{2i}^{*} = \delta_2 + \gamma y_{1i}^{*} + x_{2i}\beta_2 + u_{2i}, \end{cases} \qquad (11)$$

where y_{1i}^{*} and y_{2i}^{*} are two latent variables that can be broadly defined as measures of profitability associated with two simultaneous decisions, and therefore are expected to be positive when corresponding decisions are observed. Vectors of explanatory variables x_{1i} and x_{2i} may have some common components (as in (10)); u_{1i} and u_{2i} are random normal variables with constant variances normalized to 1, and a correlation coefficient denoted ρ. We assume the following exogeneity restrictions apply: $E(x_{1i}u_{1i}) = E(x_{2i}u_{2i}) = 0, \forall i$.

In our case, latent variables are associated with decisions on the extension of cotton land and total farmland, the precise matching of y_{1i}^{*} and y_{2i}^{*} to these decisions in (11) above depending on assumptions made on the data generating process. We may assume that extension of land for cotton depends explicitly on total farmland extension given other explanatory variables, in which case the former would correspond to y_{2i}^*, the latter to y_{1i}^* and other explanatory variables to x_{2i}, or the opposite. Latent variables can lie in the real line, to be consistent with the fact that profitability may be defined according to a set of non-overlapping intervals, typically from large negative values to large and positive values, and including areas where profitability is more uncertain (around 0 in particular). Let $\left\{S_j^k = [c_{j-1}^k, c_j^k]\right\}$, $j = 1,2,\ldots,J_k$; $k = 1,2$ denote such sets, with $\bigcup_j S_j^k = \mathbb{R}, \forall k = 1,2$, and such that $c_0^k = -\infty, c_{J_K}^k = \infty, \forall k,$ and $c_{j-1}^k \leq c_j^k, \forall k, \forall j$. We observe the following ordered dependent variables: $y_{1j} = 1$ if $y_{1i}^* \in S_j^1$ and $y_{2k} = 1$ if $y_{2i}^* \in S_k^2$, $j = 1,2,\ldots,J_1, k = 1,2,\ldots,J_2$. From the structural model (2) and (3) we have:

$$
\begin{aligned}
\Pr ob(y_{1i}^* \in S_j^1, y_{2i}^* \in S_k^2) &= \Pr ob(y_{1i} = j, y_{2i} = k) = \Pr ob(c_{j-1}^1 \leq y_{1i}^* < c_j^1, c_{k-1}^2 \leq y_{2i}^* < c_k^2) \\
&= \Phi_2\left[c_j^1 - \delta_1 - x_{1i}\beta_1, \theta\left(c_k^2 - \gamma\delta_1 - \gamma x_{1i}\beta_1 - \delta_2 - x_{2i}\beta_2\right), \bar{\rho}\right] \\
&- \Phi_2\left[c_{j-1}^1 - \delta_1 - x_{1i}\beta_1, \theta\left(c_k^2 - \gamma\delta_1 - \gamma x_{1i}\beta_1 - \delta_2 - x_{2i}\beta_2\right), \bar{\rho}\right] \\
&- \Phi_2\left[c_j^1 - \delta_1 - x_{1i}\beta_1, \theta\left(c_{k-1}^2 - \gamma\delta_1 - \gamma x_{1i}\beta_1 - \delta_2 - x_{2i}\beta_2\right), \bar{\rho}\right] \\
&+ \Phi_2\left[c_{j-1}^1 - \delta_1 - x_{1i}\beta_1, \theta\left(c_{k-1}^2 - \gamma\delta_1 - \gamma x_{1i}\beta_1 - \delta_2 - x_{2i}\beta_2\right), \bar{\rho}\right],
\end{aligned} \tag{12}
$$

where $\Phi_2(\bullet,\bullet,\bullet)$ is the bivariate standard normal cumulative distribution function, and $\theta = \left(1 + 2\gamma\rho + \gamma^2\right)^{-1/2}$, $\bar{\rho} = \theta(\gamma + \rho)$.

The formula for the probability of any pair *(j, k)* can be used to construct the log-likelihood of the sample, and to obtain consistent Maximum Likelihood estimates of the bivariate ordered Probit (see Sajaia, 2007). $J_1 + J_2 - 2$ cut off values (c_j^k) are estimated together with parameters $(\beta_1, \beta_2, \gamma, \rho)$, but intercept terms δ_1 and δ_2 are not identified (equivalently, cut offs are only identified up to a constant term). Parameters in the system (11) are identified only if exclusion restrictions are imposed, namely at least one variable in x_{1i} should be excluded from x_{2i}. An interesting candidate as an exogenous variable in the determination of total farmland evolution while not being correlated with crop allocation evolution -and land share dedicated to cotton- is the ethnical origin, but with experience in cotton growing as a control variable. This follows directly from our discussion in the beginning of this section.

A particularly interesting special case is the bivariate (binary) Probit model, which obtains under the restriction that $J_k = 2, k = 1, 2$. Such a restriction would be justified if, for instance, a single cut off value for each equation is significantly different from 0 in the bivariate ordered Probit model. This alternative model is considered in the following, when extension of land for cotton or total land farm is represented by a dichotomous dependent variable coded as "negative or moderate increase" versus "large increase". Whether we consider the general model as the bivariate ordered Probit model, or the bivariate binary Probit specification, endogeneity of y_2^* as an explanatory variable in equation (11) has to be accounted for. If error terms u_{1i} and u_{2i} are correlated ($\rho \neq 0$), this implies that y_{1i}^* is correlated with u_{2i} and therefore the second equation in the system of equations (11) cannot be estimated independently. In our empirical analysis of joint determination of total farm land and land for cotton, this endogeneity issue is indeed crucial.

There are two ways of testing for possible endogeneity of y_1^* in the equation for y_2^* in the system of equations (11) above. The first one is proposed by Rivers and Vuong (1988), and considers separate estimation of the system (11). The method is based on a first-stage OLS regression of the potentially endogenous variable (y_{1i}) on exogenous explanatory variables (x_{1i}). In the second stage, computed residuals of the first-stage regression are included in the Probit estimation of the second equation together with y_{1i} and x_{2i} as regressors. If the estimated parameter on predicted residuals is significant, then exogeneity of y_{1i} in the second equation of (11) is rejected. The advantage of this testing procedure is that it only requires single-equation least squares and (ordered) Probit estimation steps. The second possibility consists in estimating the structural system of equations (10) by bivariate (ordered) Probit and then use a Wald Test of $\gamma = 0$ in the second one. Sajaia (2007) provides a method for computing this test in the bivariate ordered Probit model, with a Full Information Maximum Likelihood (FIML) approach. It should be noted that we do not consider, for the sake of space limitation, an alternative estimation method, the bivariate Probit corresponding to the reduced form of the system. Although this model could be employed to yield consistent parameter estimates as long as exogeneity of y_2^* in the sense defined above is rejected, we are able to obtain structural parameter estimates directly by FIML with the bivariate ordered Probit procedure.

To summarize, our estimation strategy is as follows. We first consider the special case of the binary Probit model, where y_1 (resp. y_2) is a dummy variable equal to 1 if the corresponding land increase is large, and 0 if it is moderate or land decreases. This special case obtains, as described above, by restricting cut off values to 0. We then test for endogeneity of y_2 using the Rivers-Vuong test procedure. The binary Probit model is also estimated under the restriction that $\gamma = 0$, i.e., without the endogeneity issue, in a bivariate framework and with the same explanatory variables. Second, we turn to the estimation of the ordered Probit model, under its single-equation expression, and then its full structural form (by FIML). In the former model, we also test for the endogeneity of y_2 by extending the Rivers-Vuong procedure to the ordered Probit case. In the latter, FIML estimates are also computed under the restriction that $\gamma = 0$. For the ordered Probit, dependent variables correspond to multinomial variables with a wider range of possible changes in farm land (resp. land for cotton): large decrease, moderate decrease, no change, moderate increase, etc. Finally, from ordered Probit parameter estimates of the cut off values, we are able to test for the validity of the restricted model (binary Probit), against the alternative of the ordered Probit.

Results and discussion

In table 1, we observe that the sample corresponds to 0.2% of national cotton production of the 2005/2006 crop season. Compared to the data of DGPSA at the national level, average crop yields and input use are quite comparable for cotton. The variability in crop yields is due to the variability in mineral (chemical) and organic (manure) fertilizer application and in access to inputs. Moreover, there is significant variability in soil fertility and experience with the cotton crop (see tables 2 and 3 in the appendix). Land distribution (table 4, in the appendix) exhibits a similar pattern to national data of DGPSA. On average, farmers apply far more nitrogen on cotton than on other crops, which partly reflects the relative profitability of cotton with respect to other crops. It is also because input access is conditioned on growing cotton and input diversion to other crops has become much more difficult. However, input use for other crops is larger than the national average, because GPCs are now able to provide cereal input credit to their members. Note that the average land share dedicated to cotton is slightly more than 50% while it was around 30% before the reform in the same region, according to DGPSA.

[Table 5 here]

We then display descriptive statistics on our variables of interest, evolution of land shares dedicated to cotton and evolution of total farmland for each household in a cross-table (see above). Two thirds of the sample[27] is composed by households who have increased their farmland during the reform or increased their land share dedicated to cotton and more than one half to households that participated to both phenomena. The correlation between these two variables is quite significant, which gives support to our empirical framework.

To be consistent with the conceptual approach, we use a set of measurable household characteristics and related cropping behavior, and statements about evolution of farmland, crop risk-profitability profiles and their evolution as explanatory variables (tables 2 and 3). The reform period covers ten years and the answers to the recall questions may cover different periods of time, reflecting the farmer's particular experience. Their children may have left the household. Or they may have sought out land when it was more readily available. More established farmers might be wealthier and have different views about risk6diversification, income and food security goals. More to the point, the information in the left-hand-side variable of (7) will be different based on the length of the period covered in the retrospective response and may therefore represent a different relationship with the right-hand-side variables. To address this crucial point, we control for the age of the household's chief and the experience in cotton growing. The latter also enables us to disentangle the effect of ethnic origin on land access as a valid instrument for the estimation strategy and to control for the effects of experience in land use evolution with respect to cotton growing.

In the binary and ordered specifications, the exogeneity tests (Rivers-Vuong and Wald) are rejected for the evolution of cultivated land when estimating evolution of land use for allocation to cotton. That means that accounting for endogenous evolution of cultivated land in the evolution of land shares allocated to cotton would yield consistent estimates. In tables 6a and 7a[28], estimates are very different and reflect an endogenous bias. It is noteworthy that relative prices and relative price variability are not significant anymore in land use evolution when we account for cultivated land endogeneity. Indeed, price concerns matter less when cultivated land increases according to (3). Everything equal, there is a positive correlation between evolution of cotton shares and cultivated land, which corroborates our first findings. This is consistent with cash income goals once food security has been achieved. Comparing tables 6a and 6b to 7a and 7b, there are more significant cut off values in the latter, so the ordered specification is a better specification since it is possible to disentangle different regimes of land use and land cropping changes. In addition, the correlation between residuals of the two equations is significant in the bivariate-ordered Probit specification, which gives support to the bivariate specification[29] and to the process' simultaneity nature. We thus focus on the estimates of the bivariate-ordered Probit specification (table 7a and 7b) with evolution of total farmland as an endogenous variable in the determination of land use evolution.

[Table 7a here]

What has driven the positive evolution of cotton as a share of total farmland lies in the importance of better market arrangements within producers and between them and cotton firms, with the limitation of food needs. The date of payment cotton seed (early in the season, compared to other crops), the importance of accessing inputs (easier when growing cotton under the new GPC institutional arrangements), and the guarantee of selling all production at once have been crucial. They also reflect less risky strategies undertaken by farmers to fulfill their income goal, compared to other crops which payments arrive later in the crop season; marketing is more risky and involve many stakeholders with no guarantee to sell production at a good price, and more difficulties to access inputs. Note that technical assistance has limited a too large increase of cotton land use, because of more financial risks bore by the cotton firms while it was the reverse in the past when extension agents were sent by the government under a cotton-promotion national strategy. The delegation of extension services to the private sector is associated to a better concern with marketing profitability and financial risks involved in the outgrower schemes for input credit. The quality of GPC relationships is not significant in the evolution of land use since it has become easier to change groups for unsatisfied producers, therefore enabling input credit to be more equally distributed.

[Table 7b here]

About the evolution of total cultivated land by household, the evolution of familial labor force and farm capital (mechanization) appear as strong determinants. This is confirmed by the estimated of the mechanization dummies where already-equipped farmers have been more likely to increase their farmland than those who have equipped during the reform, and much more than those who are still cropping in a traditional fashion (with no animals). Note that the increase in village labor force (release of labor shortage constraints) and better technical and managerial skills (input allocation and efficiency) have also significantly played on the general pattern of cultivated land increase. Finally, ethnic origin also explains better land access for resident ethnic groups than others, when experience in cotton growing and village residence length are accounted for. The use of ethnic origin as an instrument for endogenous evolution of total farmland is thus justified.

Because the Rivers-Vuong statistics captures endogeneity and possible residual covariance, the estimates of univariate Probits are close to the bivariate endogenous ones. Note that once we controlled for all determinants, residuals are still negatively and significantly correlated. To discuss the relative size of the several effects identified earlier, we look at the marginal effects computed on the single-equation binary Probit with the Rivers-Vuong estimate, which allows easier interpretations (table 8, see in the appendix).

Among the several statements made by farmers, the most important effects come from the concern for payment date (more than 6%), followed by guarantee of selling (almost 4%), and input access (more than 2%) in the probability of large increase in cotton land use. The concern for food needs has a negative marginal impact of more than 1%. Note that an additional visit of a technical agent today has a negative marginal impact of 1.7% on this probability while it was positive before the reform (around 2%). For the probability of large increase in total farmland, increase in labor force (2.7%) and evolving farming system (1.7%) are the most important marginal effects among farmers' statements. Indeed, already-equipped farmers are more likely (more than 50% more) to have experienced a large increase in cultivated land than non-equipped ones, while those who adopted animal-drawn farming during the reform have 16% more. Belonging to a resident ethnic group also increases this probability by 11%, traducing an ethnicity bias in land allocation. This partly confirms the results of Gray and Kevane (2001).

Better institutional arrangements have driven the potential for cotton production in the region, through more incentives for land use in favor of cotton and indirect effects -through labor and capital investment, and better allocation of factors- for land cultivation. While relative prices have not significantly impacted farmers' behavior, their institutional environment has generated a more secured access to inputs, and better market relationships with cotton stakeholders. This has substantially decreased the relative risk profile of cotton with respect to other crops while the increase in total farmland has secured farmers for their food security objectives. However, the channels whereby elements of the reform have played on land extension remain unclear. Additional data would be helpful in this regard[30].

The spectrum of new difficulties faced by the Burkinabè cotton sector[31] actually reveals that extensive cotton production is not sustainable in the long-run if cotton firms and banks cannot recover their loans anymore[32]. The new deficits experienced last years by cotton firms resulted in new difficulties to pay farmers (with bad agro-climatic conditions), which has led to a stop of the cotton "boom"[33]. A policy-led intensification of farming systems is expected, and this could be based on the same institutional mechanisms than those of the cotton reform; namely the involvement and empowerment of producers in the political process together with a sufficient degree of market coordination among stakeholders. Then, a new challenge for research should be the focus on the conditions for emerging institutions –both formal and informal- that support specific solutions to coordination problems in key commodity sectors, such as cotton in Burkina Faso[34]. This would bring new insights for agricultural policymaking in the region with a special interest in the institutional design of African rural societies.

References

Abdoulaye, Tahirou, and John H. Sanders. 2006. "New Technologies, Marketing Strategies and Public Food Policy for Traditional Food Crops: Millet in Niger". *Agricultural Systems* 90:279-92.

Akiyama, Takamasa, Baffes, John, Larson, Donald F., and Panos Varangis. 2001. *Commodity Market Reforms: Lessons of two Decades.* Washington, DC: World Bank Publications.

Azam, Jean-Paul, and Nadjiounoum Djimtoingar. 2007. "Cotton, War and Growth in Chad (1960-2000)." In Benno J. Ndulu, Stephen A. Connell, Jean-Paul Azam, Robert H. Bates, Augustin Fosu, Jan Gunning and Dominique Njinkeu (eds.): *The Political Economy of Economic Growth in Africa, 1960-2000*, *Vol.2: Country Case Studies,* 86-115. Cambridge, MA: Harvard University Press.

Baffes, John. 2004. "Cotton: Market Setting, Trade Policies, and Issues." World Bank Working paper, Washington, DC.

Bassett, Thomas. 2001. *The Peasant Cotton Revolution in West Africa, Côte d'Ivoire, 1880-1995.* Cambridge, UK: Cambridge University Press.

Besley, Timothy, and Anne Case, 1994. "Diffusion as a Learning Process: Evidence from HYV Cotton". Working paper, Woodrow Wilson School of Public and International Affairs, Research Program in Development Studies, Princeton University: USA.

Brambilla, Irene, and Guido G. Porto. 2005. "Farm Productivity and Market structure: Evidence from cotton reforms in Zambia." Working paper, Economic Growth Center, Yale University: Massachusetts, USA.

Conley, Timothy G. and Chris Udry. 2000. "Learning about a New Technology: Pineapple in Ghana." Working paper, Economic Growth Center, Yale University.

De Janvry, Alain, Fafchamps, Marcel and Elisabeth Sadoulet. 1991. "Peasant Household Behaviors with Missing Markets: Some Paradoxes explained". *Economic Journal* 101: 1400-17.

DGPSA (*Direction générale des prévisions statistiques agricoles)*. 1993-2005. Permanent agricultural survey data. Ouagadougou: Burkina Faso.

Fafchamps, Marcel. 1992. "Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World." *American Journal of Agricultural Economics 74(1)*: 90-9.

Foster, Andrew, and Mark Rosenzweig. 1995. “Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture.” *Journal of Political Economy* 103(6): 1176-209.

Goreux, Louis. 2003. “Reforming the cotton sector in Sub-Saharan Africa.” World Bank Working paper, Washington, DC.

Gray, Leslie C., and Michael Kevane. 2001. “Evolving Tenure Rights and Agricultural Intensification in Southwestern Burkina Faso.” *World Development* 29(4): 573-87.

INSD (*Institut National des Statistiques et de la Démographie*). 2006. National demographics census and living standards survey data. Ouagadougou: Burkina Faso.

Jayne, Thomas. 1994. “Do High Food Marketing Costs Constrain Cash Crop Production? Evidence from Zimbabwe.” *Economic Development and Cultural Change* 30: 387-402.

Jayne, Thomas, Shaffer, James D., Staatz, John M., and Thomas Reardon. 1997. “Improving the Impact of Market Reform on Agricultural Productivity in Africa: How Institutional Design Make a Difference.” MSU International Development Working Paper No. 66, Michigan State University, East Lansing: Michigan, USA.

Kaminski, Jonathan. 2007. “Interlinked Agreements and the Institutional Reform in the Cotton Sector of Burkina Faso.” Working paper, ARQADE, Toulouse School of Economics.

Poulton, Colin., Gibbon, Peter, Hanyani-Mlambo, Benjamine, Kydd, Jonathan, Maro, Wilbald, Larsen, Marianne N., Osorio, Afonso, Tschirley, David, and Ballard Zu. 2004. “Competition and Coordination in Liberalized African Cotton Market Systems.” *World Development* 32(3): 519-36.

Rivers, Douglas, and Quang H. Vuong. 1988. “Limited Information Estimators and Exogeneity Tests for Simultaneous Probit Models.” *Journal of Econometrics* 39: 347-66.

Sajaia, Zurab. 2007. “Maximum Likelihood Estimation of a Bivariate Ordered Probit Model: Implementation and Monte Carlo Simulations.” Draft Version, World Bank, Washington, DC.

Savadogo, Kimseyinga, and Takeshi Sakurai. 2007. “War Induced Covariate Shocks and Natural Resource Degradation in Burkina Faso: Evidence from the Ivorian Crisis”. Working Paper: Ouagadougou, Burkina Faso.

Sawadogo, Jean-Pierre, and Volker Stamm. 2000. “Local Perceptions of Indigenous Land Tenure Systems: Views of Peasants, Women, and Dignitaries in a Rural Province of Burkina Faso.” *Journal of Modern African Studies* 38(2): 279-94.

Tanguy, Bernard, Collion, Marie-Helene, de Janvry, Alain, Rondot, Pierre, and Elisabeth Sadoulet. 2008. "Do Village Organizations Make a Difference in African Rural

Development? A Study for Senegal and Burkina Faso." *World Development* 36(11): 2188-204.

Stamm, Volker. 1994. "Non-Commercial Systems of Land Allocation and their Economic Implications: Evidence from Burkina Faso." *Journal of Modern African Studies* 32(4):713-7.

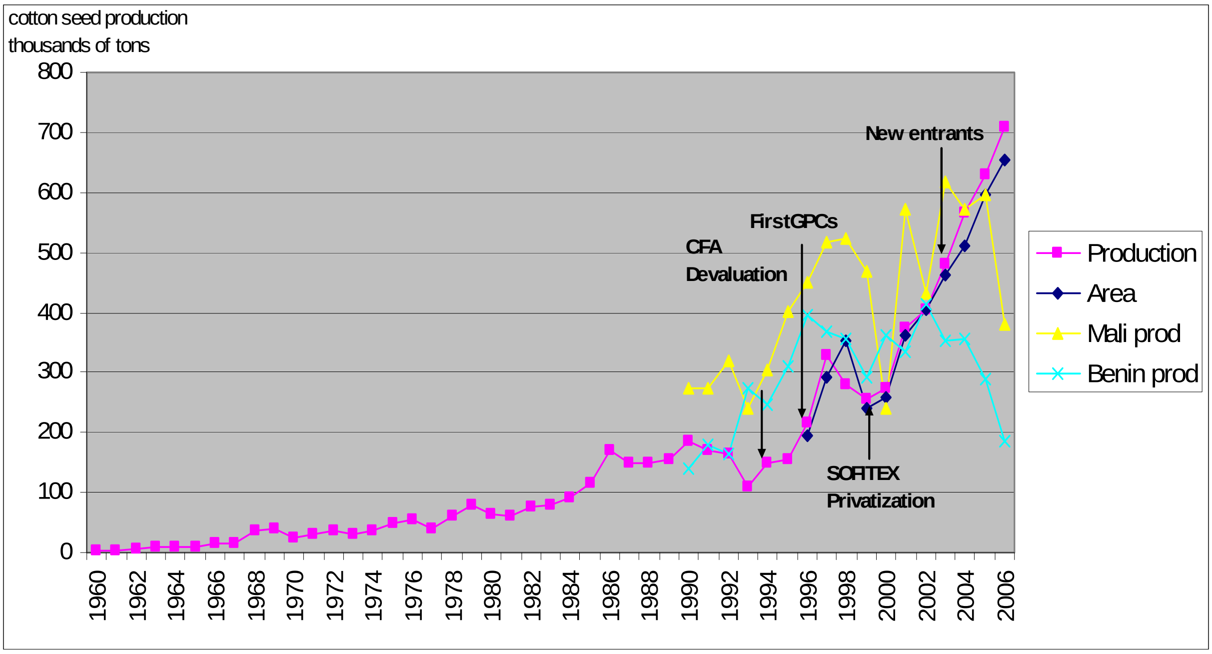
Udry, Christopher. 1996. "Gender, Agricultural Production and the Theory of the Household". *Journal of Political Economy* 104(5):1010-46.

Udry, Christopher and Markus Goldstein. 2008. "The Profits of Power: Land Rights and Agricultural Investment in Ghana." Forthcoming in *Journal of Political Economy*.

World Bank. 2004. "Cotton Cultivation in Burkina Faso, a 30 years success story." Paper presented at the Conference "Scaling up Poverty Reduction, a Global Learning Process", Shanghai, China.

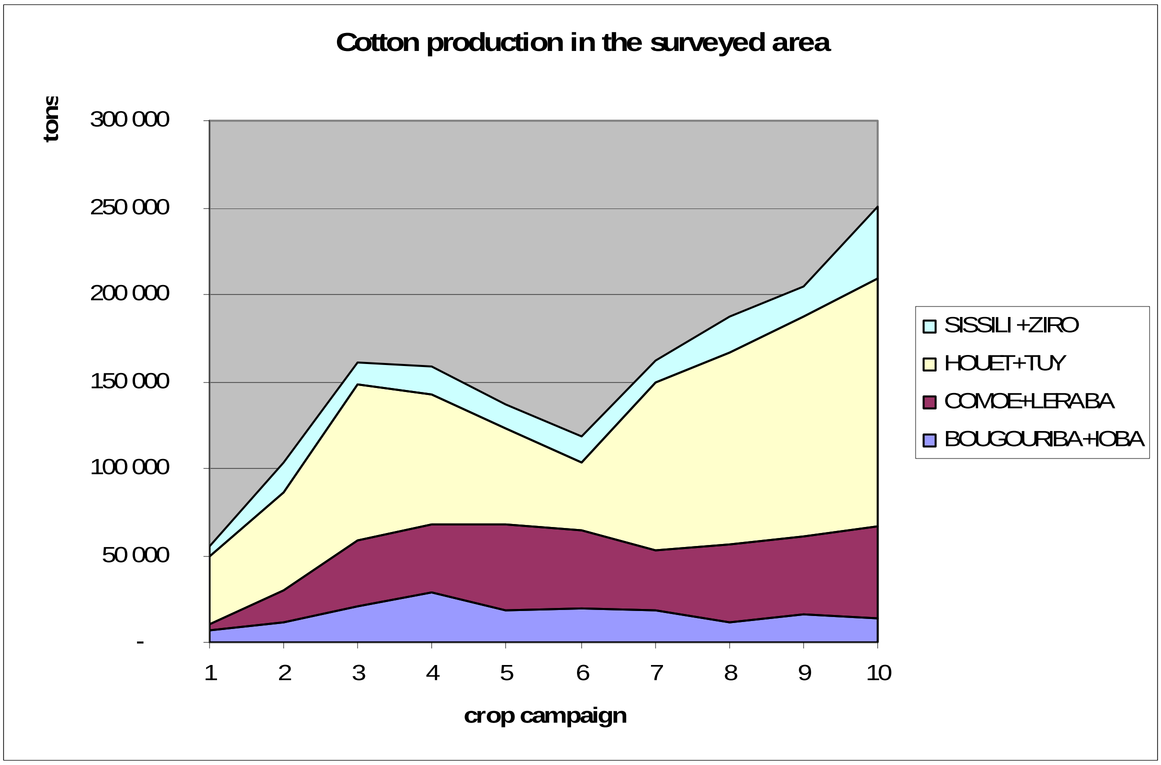
Appendix

Figure 1. Cotton areas and production during the reform and experience of neighbors



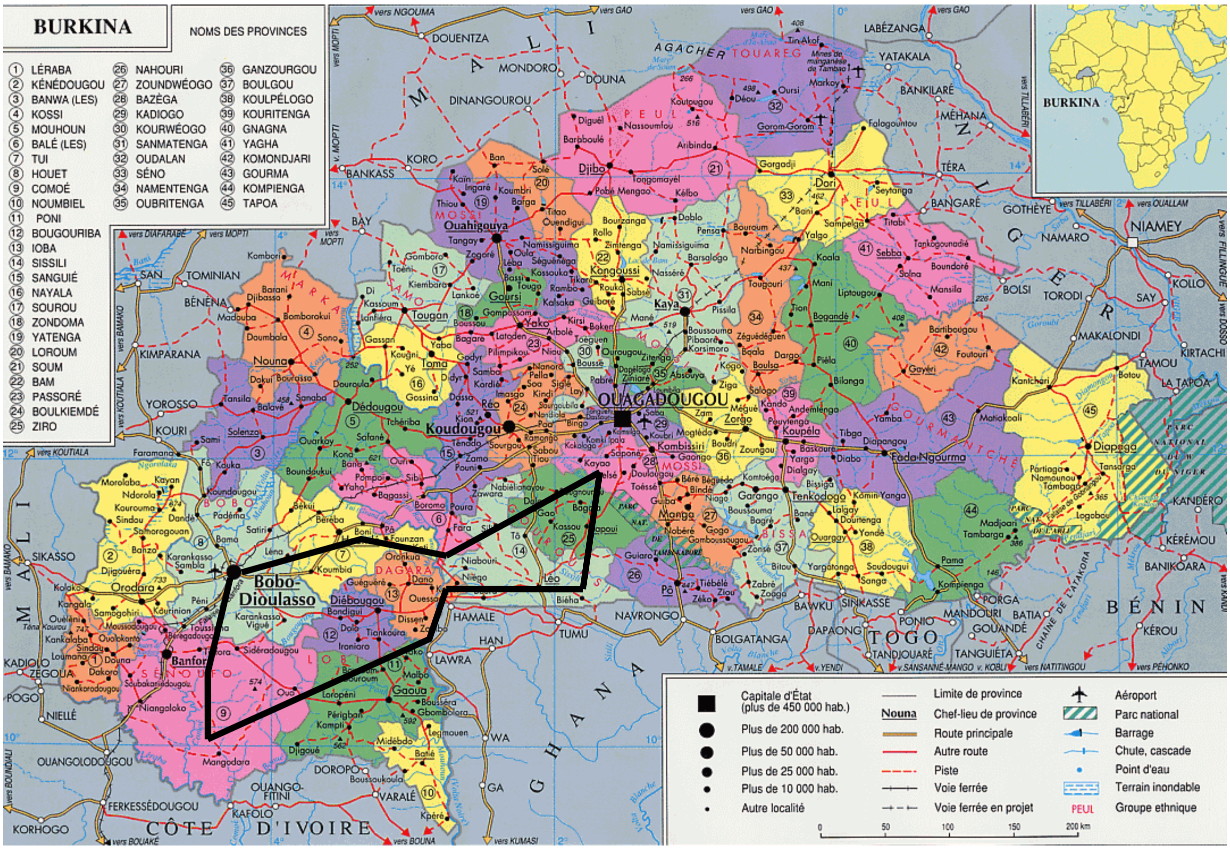
Source: ICAC (2006) and DGPSA (2006)

Figure 2. Representativity of the surveyed area -Cumulative and regional production patterns between 1995 and 2005



Source: DGPSA (2006)

Figure 3. Sampling area



Source: *Division Géographique du Ministère des Affaires Etrangères de France* (Geographic Department of the French Ministry of Foreign Affairs)

Table 1. Descriptive statistics of the sample for household crop production in 2006

Observations: 300

Cotton	Total	Mean	Median	Std. deviation	Min	Max	National level
Cotton seed output (kg)	1206266	4034.33	2373	5083.97	201	49640	710.10^6
Yield (kg/ ha)		1037.17	1002	359.94	201	2073.33	1050
Urea (kg/ ha)		68.85	50	52.13	0	533.33	62.4
Chemical fertilizer (kg/ ha)		110.77	100	60.53	0	600	103.7
Organic fertilizer (kg/ ha)		13.40	0	65.43	0	1000	-
Pesticide (liter/ ha)		5.39	6	2.36	0	24	4.92
Planted Area (ha)	1092.75	3.67	2.5	3.52	0.5	25	675.10^3
Other crops							
Urea (kg/ ha)		18.32	0	34.58	0	250	7.2
Chemical fertilizer (kg / ha)		27.17	0	52.07	0	400	12 .8
Organic fertilizer (kg/ ha)		21.67	0	105.78	0	1600	-
Pesticide (liter/ ha)		0.15	0	0.77	0	8.67	0.0
Area (ha)	985.95	3.29	3	1.33	1	15	-

Note: national data are estimates computed from the permanent agriculture survey data of DGPSA.

Table 2. Description of continuous and discrete quantitative variables

Variable name	Description	Mean	SE
Age	Age of the household's chief in years	34	8.08
Technical assistance level	Number of visits of technical agents in 2005/2006	2.95	5.69
Past technical assistance level	Number of visits of technical agents 10 years ago	1.95	2.84
Risk aversion	Relative risk aversion index for a harvest value of 100,000 FCFA	0.71	.021
Off-farm income	Household off-farm income (non-farm and transfers) in thousands FCFA	13.5	29.0
Relative input	Ratio of total mineral fertilizers applied on cotton/other crops by hectare	2.07	1.24
Family labor force	Importance of increase in family labor force during the reform to explain farmland growth[35]	3.24	3.53
Village labor force	Importance of increase in village labor force during the reform to explain farmland growth	2.03	2.81
Agricultural system	Importance of the evolution in agricultural system (mechanization, animal farming) during the reform to explain farmland growth	3.02	3.75
Technical abilities	Importance of increase in technical abilities during the reform to explain farmland growth	1.22	2.36
Managerial abilities	Importance of increase in management abilities during the reform to explain farmland growth	0.94	2.14
Relative price	Importance of prices in deciding crop allocation	4.12	3.81
Relative price variability	Importance of prices fluctuations in deciding crop allocation	2.3	3.17
Financial needs	Importance of financial needs in deciding crop allocation	3.57	3.69
Food needs	Importance of food needs in deciding crop allocation	2.61	3.18
Guarantee of selling	Importance of guarantee of selling crops in deciding crop allocation	2.78	3.44
Input access	Importance of access to inputs in deciding crop allocation	2.95	2.53
Payment date	Importance of dates of crop payments in deciding crop allocation	0.36	1.49
Technical advices	Importance of technical advices by technical agents and cooperatives when deciding crop allocation	0.91	2.13

Table 3. Description of categorical, ordered and dummy variables

Variable name	Variable type and description	Frequency
Big increase in land share dedicated to cotton	Dummy variable on the growth of land share for cotton during the reform=1 if the household has experienced a big increase in land share devoted to cotton crop	0.423
Significant increase in total farmland	Dummy variable on farmland growth during the reform, =1 if the household has experienced a farmland growth more than 2 ha over the last ten years	0.273
Evolution of land shares dedicated to cotton	Ordered variable on the evolution of land share for cotton during the reform,	
	=1 if land share for cotton has much decreased	0.003
	=2 if land share for cotton has slightly decreased	0.057
	=3 if land share for cotton has remained constant	0.183
	=4 if land share for cotton has slightly increase	0.33
	=5 if land share for cotton has much increased	0.423
Evolution of total farmland by household	Ordered variable on the evolution of farmland areas during the reform,	
	=1 if farmland areas have decreased	0.043
	=2 if farmland areas have remained constant	0.283
	=3 if farmland areas have risen by less than two ha	0.4
	=4 if farmland areas have risen by less than three ha	0.127
	=5 if farmland areas have risen by less than five ha	0.073
	=6 if farmland areas have risen by more than five ha	0.073
Mechanization system	Categorical variable on the mechanization of agricultural systems,	
	=1 if the household has adopted animal drawn farming during the reform	0.607
	=2 if the household has a traditional technology	0.197
	=3 if the household has adopted animal drawn farming before the reform	0.197
Cotton experience	Ordered variable on the household experience with cotton growing,	
	=1 if one year experienced with cotton growing	0.033
	=2 if less than three year experienced with cotton growing	0.093
	=3 if less than five year experienced with cotton growing	0.143
	=4 if less than ten years experienced with cotton growing	0.24
	=5 if more than ten years experienced (growing cotton before the reform)	0.49
Resident ethnic group	Dummy variable on the ethnical group type of the household,	
	=1 if the household belongs to a resident (in contrast to a migrant) ethnic group	0.603
GPC relationships	Categorical variable on the quality of relationships within the cotton group,	
	=1 if good	0.347
	=2 if correct	0.55
	=3 if unpleasant	0.09
	=4 if very bad	0.013

Table 4. Evolution of total cultivated land versus present farmland

Total farmland (over the 10 last years)	Present total farmland < 2 ha	[2, 5] ha	[5, 10] ha	[10,15] ha	> 15 ha	Total number of households
Decreased	2	6	5	0	0	13
Remained constant	5	49	25	5	1	85
Has increased < 1 ha	8	59	40	10	3	120
Has increased [1, 2] ha	1	11	16	7	3	38
Has increased [2, 5] ha	0	2	8	8	4	22
Has increased > 5 ha	0	1	6	7	8	22
Total number of households	16	128	100	37	19	300

Table 5. Evolution of total cultivated land versus evolution of land share allocated to cotton

Evolution of farmland	Evolution of land share allocated to cotton: Much increased	Slightly increased	Remained constant	Slightly decreased	Much decreased	Total number of households
Decreased	3	7	2	1	0	13
Remained constant	23	26	30	5	1	85
Has increased by less than 1 ha	56	41	19	4	0	120
Has increased between 1 and 2 ha	18	15	3	2	0	38
Has increased between 2 and 5 ha	13	5	0	4	0	22
Has increased by more than 5 ha	14	6	1	1	0	22
Total number of households	127	100	55	17	1	300

Table 6a and 6b. Binary Probit estimates of a large increase in land shares allocated to cotton and in farmland

Large increase in land shares allocated to cotton	Single-equation binary Probit	Bivariate binary Probit
Explanatory variables		
Relative price	.033 (.026)	.070 (.025)***
Relative price variability	-.042 (.031)	-.062 (.030)**
Financial needs	-.015 (.024)	-.003 (.023)
Food needs	-.033 (.025)	-.030 (.024)
Guarantee of selling	.099 (.030)***	.104 (.030)***
Input access	.057 (.027)**	.058 (.027)**
Payment date	.159 (.074)**	.135 (.072)*
Technical advices	-.074 (.045)*	-.075 (.044)*
Technical assistance level	-.044 (.014)***	-.037 (.013)***
Past technical assistance level	.051 (.030)*	.059 (.029)**
Relative input	-.042 (.076)	-081 (.075)
Risk aversion	-.349 (.450)	.094 (.432)
Age	-.005 (.011)	-.002 (.010)
New cotton grower	.961 (.420)**	.584 (.446)
Cotton experience <3 years	-.225 (.350)	-.691 (.345)**
Cotton experience <5 years	.533 (.279)**	.124 (.266)
Cotton experience < 10 years	.345 (.196)*	.143 (.184)
Cotton grower >10 years	reference	reference
Significant increase in total farmland	1.636 (.399)***	-
Rivers-Vuong endogeneity test	-1.782 (.431)***	-
Constant	-.551 (.883)	-.648 (.924)
Village effects and GPC relationships controlled		
Wald Chi²	71.72***	161.56***
Pseudo R²	.179	.239
ρ (bivariate Probit)	-	-0.169 (.134)
Observations	300	300

Large increase in total farmland	Single-equation binary Probit	Bivariate binary Probit
Explanatory variables		
Family labor force	.105 (.028)***	.106 (.028)***
Village labor force	.040 (.035)	.040 (.035)
Agricultural system	.065 (.030)**	.067 (.029)**
Technical abilities	.063 (.045)	.065 (.045)
Managerial abilities	.007 (.044)	.009 (.044)
Technical assistance level	.024 (.014)*	.021 (.013)*
Past technical assistance level	-.005 (.032)	-.001 (.031)
Adopt animal farming < 10 years	.683 (.343)**	.679 (.340)**
Traditional farming	reference	reference
Already animal farming (>10 years)	1.608 (.374)***	1.592 (.372)***
Length of village residence	-.004 (.006)	-.004 (.006)
Resident ethnic group	.459 (.240)*	.493 (.231)**
Off-farm income	-.001 (.003)	-.001 (.003)
Risk aversion	.727 (.641)	.671 (.622)
Age	.003 (.011)	.003 (.011)
New cotton grower	-.580 (.685)	-.493 (.694)
Cotton experience <3 years	-.663 (.528)	-.724 (.502)
Cotton experience <5 years	-.842 (.326)**	-.851 (.328)***
Cotton experience < 10 years	-.093 (.221)	-.083 (.218)
Cotton grower >10 years	reference	reference
Large increase in land share allocated to cotton	.338 (.538)	-
Rivers-Vuong endogeneity test	-.566 (.578)	-
Constant	-3.158 (.772)***	-3.014 (.726)***
Village effects controlled		
Wald Chi²	92.12***	161.56***
Pseudo R²	.352	.239
ρ (bivariate Probit)	-	-0.169 (.134)
Observations	300	300

Notes: robust standard errors in parentheses, * is significant at 10 %, ** is significant at 5 %, *** is significant at 1 %. The first set of explanatory variables contains subjective ones (see the text and Tables 6 and 7 for a description of variables). The Rivers-Vuong test is used to test for the endogeneity of a significant increase in total farmland. The Wald test statistic corresponds to the null hypothesis that the parameter associated with a significant increase in total farmland is not significantly different from 0.

Table 7a. Ordered discrete choice models and estimates for the evolution of land shares dedicated to cotton over the last ten years

Evolution of land shares allocated to cotton	Single-equation Ordered Probit	Bivariate Ordered Probit (FIML) I	Bivariate Ordered Probit (FIML) II
Explanatory variables			
Relative price	.022 (.022)	.050 (.020)**	.021 (.021)
Relative price variability	-.026 (.023)	-.038 (.025)	-.026 (.024)
Financial needs	-.009 (.020)	.005 (.020)	-.006 (.020)
Food needs	-.056 (.022)***	-.053 (.021)***	-.054 (.020)***
Guarantee of selling	.084 (.025)***	.092 (.025)***	.080 (.024)***
Input access	.060 (.024)***	.063 (.024)***	.057 (.023)***
Payment date	.169 (.052)***	.145 (.062)**	.157 (.060)***
Technical advices	-.065 (.038)*	-.062 (.038)*	-.056 (.037)
Technical assistance level	-.040 (.012)***	-.042 (.012)***	-.038 (.012)***
Past technical assistance level	.056 (.022)***	.062 (.028)**	.054 (.027)**
Relative input	-.021 (.068)	.166 (.352)	-.030 (.059)
Risk aversion	-.217 (.348)	-.057 (.060)	-.071 (.354)
Age	-.003 (.008)	.000 (.009)	-.004 (.009)
New cotton grower	.583 (.473)	.390 (.413)	.516 (.414)
Cotton experience <3 years	-.325 (.207)	-.524 (.236)**	-.339 (.240)
Cotton experience <5 years	.329 (.214)	.200 (.206)	.295 (.206)
Cotton experience < 10 years	.010 (.175)	.004 (.167)	.012 (.166)
Cotton grower >10 years	reference	reference	reference
Evolution of total farmland	.398 (.097)***	-	.335 (.080)***
Rivers-Vuong endogeneity test	-.435 (.121)***	-	-
Constant 1	-2.031 (.762)***	-2.620 (.811)***	-2.017 (.806)***
Constant 2	-.764 (.641)	-1.370 (.739)**	-.815 (.735)
Constant 3	.253 (.643)	-.371 (.733)	.153 (.729)
Constant 4	1.346 (.647)***	.675 (.734)	1.196 (.732)*
Village effects and GPC relationships	yes	yes	yes
Wald Chi²	98.85***	65.77***	87.44***
Pseudo R^2	.120	.198	.211
ρ (bivariate Probit)	-	-.024 (.081)	-.318 (.099)***
Observations	300	300	300

Notes: robust standard errors are in parentheses. * is significant at 10 %, ** is significant at 5 %, *** is significant at 1 %. The first set of explanatory variables contains subjective ones (see Tables 6 and 7 for a description of variables). The Rivers-Vuong test is used to test for the endogeneity of the evolution of total farmland. The Wald test statistic corresponds to the null hypothesis that the parameter of the evolution of total farmland is not significantly different from 0.

Table 7b. Ordered choice models and estimates for the evolution of total farmland over the last ten years

Evolution of total farmland	Single-equation Ordered Probit	Bivariate Ordered Probit (FIML) I	Bivariate Ordered Probit (FIML) II
Explanatory variables			
Family labor force	.198 (.023)***	.198 (.023)***	.198 (.023)***
Village labor force	.095 (.028)***	.095 (.027)***	.097 (.027)***
Agricultural system	.122 (.025)***	.122 (.022)***	.118 (.022)***
Technical abilities	.054 (.035)	.055 (.032)*	.056 (.031)*
Managerial abilities	.052 (.035)	.052 (.035)	.059 (.034)*
Technical assistance level	.006 (.011)	.009 (.012)	.006 (.011)
Past technical assistance level	-.006 (.022)	-.005 (.025)	-.008 (.024)
Adopt animal farming < 10 years	.557 (.189)***	.559 (.195)***	.573 (.189)***
Traditional farming	reference	reference	reference
Already animal farming (>10 years)	1.056 (.269)***	1.062 (.234)***	1.094 (.226)***
Length of village residence	-.012 (.004)***	-.012 (.005)***	-.012 (.004)***
Resident ethnic group	.468 (.171)**	.469 (.165)***	.544 (.160)***
Off-farm income	-.001 (.002)	-.001 (.002)	-.002 (.002)
Risk aversion	-.421 (.338)	-.433 (.370)	-.479 (.366)
Age	.004 (.008)	.004 (.009)	.004 (.009)
New cotton grower	-.109 (.372)	-.115 (.375)	-.116 (.375)
Cotton experience <3 years	-.075 (.243)	-.059 (.262)	-.040 (.260)
Cotton experience <5 years	-.163 (.212)	-.162 (.216)	-.158 (.215)
Cotton experience < 10 years	.215 (.169)	.218 (.171)	.213 (.171)
Cotton grower >10 years	reference	reference	reference
Evolution of land shares allocated to cotton	-.034 (.188)	-	-
Rivers-Vuong endogeneity test	.023 (.201)	-	-
Constant 1	-1.147 (.953)	-1.012 (.448)**	-0.976 (.446)**
Constant 2	0.838 (946)	.971 (.437)**	.982 (.434)**
Constant 3	2.750 (.966)***	2.883 (.461)***	2.888 (458)***
Constant 4	3.420 (.971)***	3.554 (.472)***	3.577 (.470)***
Constant 5	4.021 (.971)***	4.155 (.486)***	4.191 (.484)***
Village effects	yes	yes	yes
Wald Chi²	237.22***	64.71***	87.44***
Pseudo R^2	.294	.198	.211
ρ (bivariate Probit)	-	-.024 (.081)	-.318 (.099)***
Observations	300	300	300

Notes: robust standard errors are in parentheses. * is significant at 10 %, ** is significant at 5 %, *** is significant at 1 %. The first set of explanatory variables contains subjective ones (see Tables 6 and 7 for a description of variables). The Rivers-Vuong test is used to test for the evolution of land shares allocated to cotton The Wald test statistic corresponds to the null hypothesis that the parameter of the evolution of land share allocated to cotton is not significantly different from 0.

Table 8. Marginal effects with single-equation binary Probits and exogeneity test

Large increase in land shares allocated to cotton Explanatory variables	Marginal effects in %	Marginal effects in %	Large increase in total farmland Explanatory variables
Relative price	1.28 (1.01)	2.68 (.73)***	Family labor force
Relative price variability	-1.62 (1.20)	1.02 (.91)	Village labor force
Financial needs	-.58 (.95)	1.66 (.80)**	Agricultural system
Food needs	-1.28 (.97)	1.63 (1.16)	Technical abilities
Guarantee of selling	3.83 (1.17)***	.18 (1.13)	Managerial abilities
Input access	2.21 (1.06)**	.61 (.37)*	Technical assistance level
Payment date	6.16 (2.87)**	-.12 (.82)	Past technical assistance level
Technical advices	-2.88 (1.77)*	16.30 (7.33)**	Adopt animal farming < 10 years
Technical assistance level	-1.69 (.55)***	reference	Traditional farming
Past technical assistance level	1.99 (1.15)*	53.28 (12.03)***	Already animal farming (>10 years)
Relative input	-1.63 (2.96)	-.09 (1.61)	Length of village residence
Risk aversion	-13.55 (17.50)	11.24 (5.56)**	Resident ethnic group
Age	-.19 (.41)	-.02 (.08)	Off-farm income
New cotton grower	36.11 (13.26)	18.63 (16.11)	Risk aversion
Cotton experience <3 years	-8.52 (12.79)	.07 (.28)	Age
Cotton experience <5 years	21.02 (10.83)**	-11.18 (9.11)	New cotton grower
Cotton experience < 10 years	13.58 (7.72)*	-12.81 (7.18)*	Cotton experience <3 years
Cotton grower >10 years	reference	-15.78 (4.43)***	Cotton experience <5 years
Significant increase in total farmland	58.20 (10.80)***	-2.34 (5.43)	Cotton experience < 10 years
		reference	Cotton grower >10 years
		8.86 (14.45)	Large increase in land share allocated to cotton

Note: robust standard errors are in parentheses, * is significant at 10 %, ** is significant at 5 %, *** is significant at 1 %. The Rivers-Vuong t-statistic and other control variables are included (same model as tables 6a and 6b).

End Notes

[1] They stem from institutional arrangements between producers and stakeholders and within producers, market institutions, and property rights.

[2] In cotton-producing Sub-Saharan areas, most farmers are cash constrained and must be financed their inputs by credit schemes. Because of credit market failures in rural areas, most of input credit schemes are interlinked arrangements between credit provision and cotton delivery. Credit recovery is challenged when several cotton purchasers -who are also input credit providers- can interact with farmers, because strategic defaulting on credit becomes more profitable and does not prevent farmers to access credit in the future. Indeed, farmers have more opportunities for side-selling that is, contracting for input credit to a particular credit provider and selling her cotton to another trader.

[3] A clearing financial house has been established in Benin to cope with input credit recovery. Because of strong rigidities (farmers and cotton firms have to declare whom they are contracting with and where to deliver cotton and inputs), private investment incentives have been weakened. In Zambia, the « distributor system » has promoted better relationships between technical agents and farmers' groups, leading to better monitoring and credit repayment incentives. According to Brambilla and Porto (2006), this is the main cause of the cotton production recovery observed over these last years. This has been conditioned on the prior establishment of stakeholders associations and cotton producers' groups.

[4] The National cotton fibers company.

[5] *Groupements villageois.*

[6] At that time, there was no efficient and transparent stabilization mechanism for prices while world prices declined.

[7] *Groupements de producteurs de coton.*

[8] *Union nationale des producteurs de coton du Burkina Faso.*
[9] *Société cotonnière du Gourma* (owned by DAGRIS).
[10] *Société cotonnière du Faso* (owned by REINHARDT).
[11] This fund was previously managed by the government to subsidize the sector but has never worked efficiently; it is now managed by the professional partnership and its purpose is to attenuate the world price variability of cotton fiber.
[12] From permanent agricultural surveys (DGPSA : *Direction Générale des Prévisions et Statistiques Agricoles*).
[13] This phenomenon was based on the large spread of cotton outgrower schemes with an increasing support from the banks to SOFITEX.
[14] In 1994, the CFA Franc was devaluated by half of its value.
[15] Between 1999 and 2006, production has continuously increased from 250,000 to 730,000 tons of cotton seed.
[16] Unfortunately, this is not true anymore because of new insolvencies and deficits from SOFITEX due to declining world prices, while prices paid to producers have been kept relatively high.
[17] See note 12.
[18] *Institut National des Statistiques et de la Démographie.*
[19] As their land share was small or non-existing before, the relative increase in land share appears as being very high while absolutely comparable to other cotton farmers.
[20] Above 150 FCFA, cotton supply is generally considered to be fairly inelastic.
[21] The functioning of these market-oriented village groups has been shown to exhibit no elite capture once elaborated governance rules have been set up (Tanguy et al., 2008).
[22] This is because of costs of soil preparation and labor with increasing marginal costs of land cultivation.
[23] This is to control for different histories in crop prices (local markets) and other social and natural characteristics: soil management, land tenure systems, evolution of communities and ethnic/religious composition, and so on.
[24] This is an instrument for the endogenous variable of the system of equations.
[25] Several provinces are part of the traditional area of production while others are recent zones of production.
[26] See figure 2 in the appendix for the production trend of each visited province where we selected villages for the survey. In figure 3, the location of the sampling area is shown within bold lines.
[27] Including cotton growers who started to produce cotton after 1996 (50% of the sample, see table 3).
[28] Not for tables 6b and 7b where land use evolution exogeneity is not rejected.
[29] Note that the correlation coefficient is not significant in the binary specification (tables 6a and 6b) because endogeneity of one of the two dependent variables is not taken into account by the bivariate binary Probit.
[30] Repeated cross-sectional data with an in-difference approach as in Brambilla and Porto (2006) would be helpful. It could be possible to use time-dummies for the different steps of the reform as explanatory variables for our system of equations (10). We suspect that larger cash incomes and better technical services have enabled farmers to invest more capital on land (mechanization) and to better allocate inputs, and in particular, labor within better managed farming systems.
[31] Arising from declining world cotton prices and increasing input prices
[32] New challenges involve the development of new technologies to improve productivities, new marketing strategies to build a stronger reputation of Burkina Faso's cotton quality and to access cheaper inputs, and investing in research and extension services. Then, it seems clear that an interesting strategy would lie in the improvement of the parallel market -local and industrial textile industries- as well as the setting of an efficient and well-managed smoothing fund to reduce the risk arising from the world market and in new efforts to improve the organization of the sector.
[33] The figures of production for 2006/2007 are 660,000 tons of cotton seed reflecting the first decrease in production over the last ten years.
[34] A comparative study between Burkina Faso, Mali, and Benin could be interesting to understand how the local political economy has shaped policymaking, farmers' cooperation, and the institutional design.
[35] All the variables described from here to the end of this table are taking values on a scale of [0, 10].