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Changing Incentives to Sow Cotton for African Farmers: Evidence from the Burkina Faso Reform

by

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Changing Incentives to Sow Cotton for African Farmers: Evidence from the Burkina Faso Reform[*]

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Abstract

Over the last 10 years, Burkina Faso has experienced a reform of its cotton sector, and is now 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. We then analyze data that we collected in rural Burkina Faso in March 2006 within this framework. 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

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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.

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

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1 Introduction

The story of cotton growth throughout Sub-Saharan Africa is a very particular one, as described in the historical survey of Bassett (2001). In contrast to a successful top-down implementation, the development of the cotton economy has been supported by small-scale peasant farmers and by a "peasant cotton revolution" as a reflection of a fast evolution of farming techniques and social organizations. Often quoted as one of the few success stories of agricultural development in Sub-Saharan Africa, the cotton sector is now one of the economic growth leading factors (see Azam and Djimtoingar, 2004) and one dominant cash crop for farmers in Sahelian regions. It is also one of the major strategies in poverty reduction for rural zones and the major source of cash inflows and export earnings for those countries (Goreux, 2003). Thus, an important arising issue is the sustainability of cotton sectors in Sub-Saharan Africa and the conditions provided for it.

Since the beginning of the 1990s, most of Sub-Saharan African cotton economies have undertaken a huge process of reforms, replacing old public monopolies, official boards or parastatals, which were mainly managing cotton markets, by private investors, cotton unions and relying more on market forces and competition (Akiyama *et al.*, 2001). This has been supported by changes in economic and social institutions from local to national scales, in the organization of markets (input sales, cotton purchases, ginning, marketing, input and rural credits) with a process of partial to full privatization of the industry and into the relationships between producers, investors and governments. This process was believed to overcome the financial insolvencies and inefficiencies arising from the management of the old centralized cotton ginning firms and to raise the competitiveness of cotton sectors in a context of low world cotton prices (see Baffes, 2004; for the explanations of this phenomenon). In Western African French-speaking countries, the reform pace has been slower with a greater involvement of the public sector than in Eastern and Austral African English-speaking countries. Each country adopted its own reform plan, with progressive adjustments. Evolution of production and cotton firm's profits are very heterogeneous across countries, depending on the way institutions have been designed and on the evolution of production incentives for farmers. A key point has to be emphasized about the design of input credit schemes for cotton growers, and about their repayment incentives. Many studies from the cotton reforms (see for example, Brambilla and Porto, 2006) show that cotton boost and financial clearing for the ginning firms are conditioned on the well functioning of input credit schemes and good rates of repayments. Hence, a central issue in cotton reforms throughout Africa lies in the design of input credit schemes and their related institutions.

Akiyama *et al.* (2001) and Goreux (2003) examine cotton reforms in African countries. They note the positive effect of the privatization of cotton sectors on prices paid to producers and on the financial situation of cotton firms. However, these studies show that some level of regulation may be desirable with the involvement of producers in the industry as well as a new institutional design. Indeed, Poulton *et al.* (2004) point out the trade-off between competition and coordination in the liberalized African cotton markets, which can lead to a coordination failure when no regulatory scheme is at work. In some cases, this has led to the collapse of input credit schemes, with low repayment rates, because of "poaching"[1]. It is noteworthy that the coordination of activities within the industry is a significant issue in an economic environment where rural markets are interlinked. Whenever unregulated liberalization occurred, cotton production plunged drastically after a short-term boom, caused by the increase in investments and new entrants. Since then, regulatory schemes with new institutions have been established to cope with this issue, as in Benin or in Zambia. The effects of the reform on national production are very heterogeneous and specific to each country: political environment, macroeconomic policies, ethnical conflicts, investment outlook, other commodity markets, agro-climatic shocks. What is relevant to emphasize is the importance of regulation and institutions in privatized cotton markets with sustainable input credit schemes. The cotton reforms are expected to

[1]This consists of the strategic defaulting in credit repayment due to the opportunities for cotton growers to borrow inputs from one ginning company and to sell cotton seed to another firm or to any trader.

impact mostly on the productivity of producer households through better inputs, research, extension services, and seeds; and on the growth of areas planted in cotton. Brambilla and Porto (2006) have studied the effects of the cotton reform on productivity in Zambia. In this paper, we focus on the effects of the cotton reform in Burkina Faso on the growth of cotton areas. Why we have focused solely on this effect will be motivated below.

In Burkina Faso, the reform consisted of setting a new institutional design before privatizing the industry, creating a partnership between ginneries and producers, and new local organizations of cotton growers to cope with input credit. The resulting large increase in repayment rates of input credit and more bargaining power for producers (Kaminski, 2007a) led to more production incentives for cotton production, attracting new farmers and new land to cotton seed production. Burkina Faso has become the first African cotton producer -production has been multiplied threefold in the last five years- 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. In Kaminski (2007a), it is mentioned that the Ivorian Crisis has not led to a significant cotton evasion from Côte d'Ivoire to Burkina Faso, but that the massive inflow of labor force in rural areas is likely to have contributed significantly to the growth of national cotton production. However, this labor force has been oriented towards the cotton sector because of new incentives generated by the sector's reform.

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. 300 households of cotton growers were interviewed in order to understand how their agricultural choices of production have evolved during the reform. Our goal is to determine whether the cotton growth can be explained by the reform of the cotton sector, and what production incentives were at work during the reform. To this end, we estimate the joint probability of changes in land allocated to cotton and in total farm land under several specifications. From our cross-sectional data that contains some recall variables, the information that we gather on these processes is available through discrete, binary and ordered variables. An appropriate econometric specification is called for because of the possible endogeneity of the explanatory variable representing changes in total farmland. We rely on the use of subjective variables that support the observed evolution of farming systems. It enables us to assess the determinants of the cotton boost and, indirectly, to match the reform's impacts to these evolutions. The role of technical assistance, mechanization and the setting of GPCs for instance, are related to the reform policy to assess the causal links between cotton reform and cotton boost, at the household level.

The first specification is the binary Probit model associated with large increases in land, compared to decreases or no change in land area. This is a special case of the ordered Probit model, in which these changes are classified into more than two possible values (large decrease, moderate decrease, no change, moderate increase, etc.). The probability of changes in land area is estimated in a single-equation framework, and in a bivariate model, for the binary and the ordered Probit cases. In each model specification, we control for the possible endogeneity of an increase in total farm land (resp. increase in land allocated to cotton) in the equation for land allocated to cotton (resp. increase in total farm land). Exogeneity of such explanatory variables is tested for, using in particular a Rivers-Vuong test statistic in the single-equation models. The estimation procedure will hence allow us to determine whether, once we control for observed components in the probability of land area variations, the increase in farm land and land allocated to cotton are joint processes or not.

The remainder of this paper is as follows. Section 2 presents the stages of the reform in the cotton sector of Burkina Faso and its effects on production. We then present the different hypotheses which will be tested from our survey data. Section 3 is devoted to the empirical setting which consists of the survey design, the description of available data and the estimation strategy. Section 4 presents the econometric estimation results and their interpretations. Section 5 concludes.

2 Ten years of changes in the cotton sector of Burkina Faso

2.1 The stages of the reform: institutional design, privatization of the cotton firm and establishment of a professional partnership

After the independence of Burkina Faso in 1960, the parastatal firm SOFITEX[2] 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[3], 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 (coordination failures, see hereafter) without credible sanctions and with increasing scopes for opportunities in rent seeking and corruption among parastatal's agents and GVs leaders[4]. As a result, SOFITEX experienced difficulties in paying producers and providing them with inputs.

The reform of the cotton sector in Burkina Faso is described at length in Kaminski (2007a).

[2] The National cotton fibers company.

[3] *Groupements villageois.*

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

The main features of the reform lie in the two following issues: 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 for their input needs but the input cost was subtracted from the value of cotton sales. In large groups, lack of peer monitoring led to opportunistic behavior and less incentives for cotton production. The first step of the reform consisted in replacing GVs by GPCs[5], 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 better peer monitoring abilities and resulted in more cooperative behavior with more flexibility in group formation. Repayment rates have increased up to 99 % and these institutions have attracted new producers.

The second step of the reform was the partial privatization of SOFITEX in 1999, when government transferred half of its capital shares to UNPCB[6], the 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 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 exclusive zones of purchasing cotton seed for each ginning firm, and SOFITEX retaining the major production area in the West. The Centre of Burkina Faso was awarded to SOCOMA[7] and

[5] *Groupements de producteurs de coton.*

[6] *Union nationale des producteurs de coton du Burkina Faso.*

[7] *Société cotonnière du Gourma* (owned by DAGRIS).

the East to FASOCOTON[8]. 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[9], administered by the inter-professional partnership.

To understand the different effects of the reform on production incentives for cotton farmers and their related channels, we need to present the determinants behind farmers' decisions when considering growing cotton, and which constraints they face. The cotton crop is not only the main provider of cash incomes in rural areas of Burkina Faso but also almost the only way to access agricultural inputs for both cotton and cereal crops. It allows farmers to get cash income very early during the crop campaign with some significant guarantees (on the purchase price of cotton seed and the future sale of all harvested cotton seed). Moreover, cotton growing is an ideal complementary crop to cereal ones in rotation-based crop systems.

The main constraints faced by farmers when planning to grow cotton is their arable land availability and adequacy with respect to cotton together with climatic conditions as well as their food self-sufficiency concerns (see next section to justify the importance of this concern). Another important factor is their technical skills (human capital) and their agricultural capital[10] as well as labor endowments. This mix of productive factors and endowments allow farmers to crop a particular amount of land with a given productivity level and to make their crop allocation choices with respect to their main idiosyncratic concerns (input access, need for cash secured incomes, risk strategies). The two channels may be correlated with some causality link.

At this point, some emphasis should be put on the role of social organizations of producers. Indeed, input access and cotton production are interlinked (see Kaminski, 2007a) and managed

[8] *Société cotonnière du Faso* (owned by REINHARDT).

[9] 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.

[10] Here we use a broad notion of agricultural capital. We consider the mechanization system of farmers (ox ploughs and other draft animals), and their available chemical and manurial inputs.

collectively in producers' groups. Depending on the functioning of these groups, input access and production incentives can be hampered. This could be encompassed into the general issue of institutional constraints. A poor functioning of producers' organizations is likely to reduce input credit availability and to raise the fixed cost of inputs. Land constraints can also reduce opportunities to grow cotton. There are two kinds of land constraints: a natural one -availability of arable and sufficiently fertile land, with not too much slope- and a social one. As no land market properly works in rural Burkina Faso, available land is attributed with respect to social networks connections and/or informal norms. Familial and ethnical background matter as they are the determinants of local social power. Therefore, they likely impact the fixed cost of land. Social organizations and social connections are encompassed into the concept of social capital.

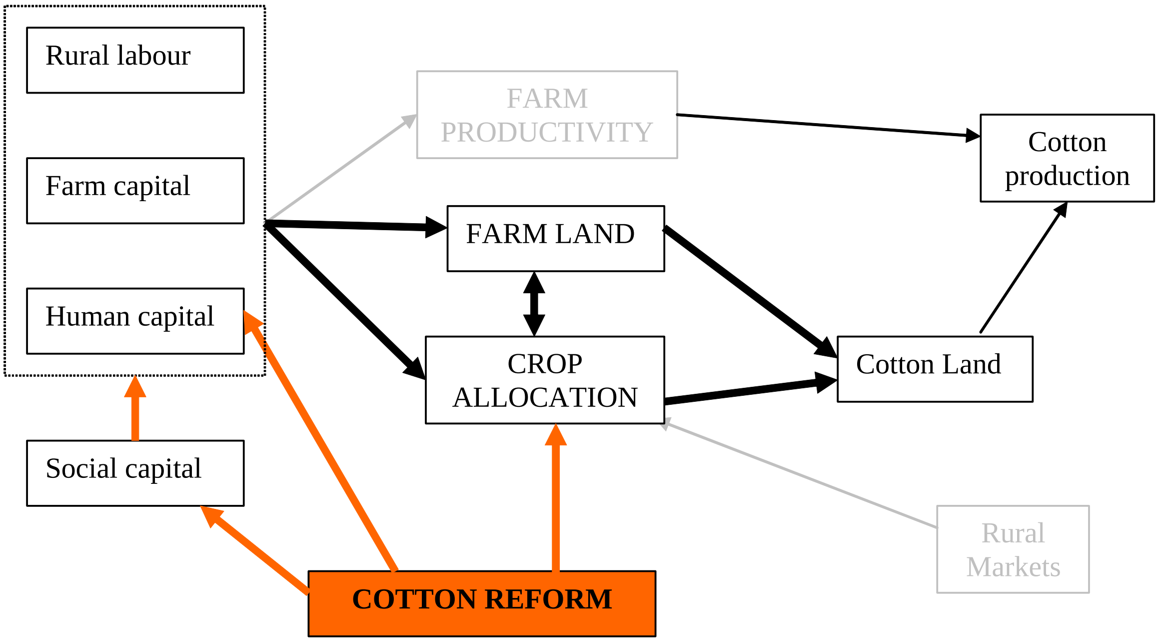

Figure 1: The channels of the cotton reform's effects on cotton areas

We present in Figure 1 the invoked channels of the reform's effect on cotton production.. The institutional reform that occurred in the Burkinan cotton sector has impacted the quality of social capital, therefore playing a major role on input access, on the mix of available factors of agricultural production and on production incentives through crop allocation choices. The role of technical assistance may have played a role on the amount of human capital and the evolution of relationships between ginners and farmers on crop allocation choices. The technical and social environments of cotton production are believed to have been responsible for the observed cotton boost. In a stable price environment for producers, the reform does not look to have changed production incentives through the price channel. However, price concerns of farmers must have been based on the relative price of cotton seed with respect to other commodity prices such as cereal local prices. Thus, rural markets should be embedded in the analysis, as exogenously influential. Finally, the impact on productivity will not be addressed in our analysis, as we focus on the extension of cotton areas.

All these channels will be formalized through the statement of testable hypotheses in the next subsections.

2.2 The pattern of production during the reform: main facts and explanations

The present subsection contains assertions and propositions which are supported by national data and censuses and by interviews with executives from the sector and local cotton experts that we met in February 2006.

Until the 1990s, the national production had grown steadily, due to the joint effect of a rise in productivity -improvement in the quality of inputs and seeds- and in cotton areas[11]. 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[12] 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 with bad repayment incentives arising from the GVs. The main changes in the organization of the cotton-related activities are displayed in the appendix of the previous chapter.

After GVs were replaced by GPCs in 1996, the production started to increase again only

[11] This phenomenon was based on the large spread of cotton outgrower schemes with an increasing support from the banks to SOFITEX.

[12] In 1994, the CFA Franc was devaluated by half of its value.

in 1999. This result was obtained because of new monitoring schemes, more credible sanctions 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 boost. The entry of new investors in 2003 brought new funds for the cotton sector, therefore participating to the cotton boost[13]. 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).

The reform plan for cotton in Burkina Faso is largely accepted to be the most successful in West Africa, as input credit access has been improved and producer prices have been maintained and even increased in spite of the declining world price of cotton fiber. The impact on production is obvious even if we have to consider other phenomena. The devaluation of the CFA Franc was responsible for the competitiveness of Burkina cotton until the end of the 1990s and the Ivorian crisis in 2002 has led hundreds of thousands of people to return to Burkina and, in particular, the traditional cotton area in the Southwest.

These latter two exogenous shocks can account for part of the production growth trend but they are not decisive (see above). For all actors of the industry and for Burkina Faso's government, the necessary condition to the reform success was the financial streamlining of the sector and more efficient credit institutions. The institutional shift from the GVs to the GPCs, and the new monitoring system allowed by the inter-professional partnership between

[13] See figure 2 in the appendix for the pattern of production over the ten last years.

producers and ginners, are the crucial elements of the high credit repayment rates of the last five crop seasons. Privatization and liberalization have improved information 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 with cotton companies, leading to more credit allowances for a growing number of producers[14].

According to the executives of cotton firms, officials and producers' representatives, 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[15], INSD[16]). The cotton growth mostly relies on area extension caused by a rapid process of mechanization in cotton regions and more labor allocated to this crop. 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[17], so that the rise in land shares allocated to cotton is partly explained by the entry of new cotton growers. 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.

The privatization process has also changed the organization of such "critical" functions of the industry as research and extension services, funded jointly by cotton companies and producer unions (see above). Research is funded by the three companies and the cotton unions, decided by the inter-professional agreement. Contributions by the 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 is more difficult with the declining cotton prices. Considered

[14] Unfortunately, it is not true anymore today because of new insolvencies and deficits from SOFITEX coming from the declining world prices whereas prices paid to producers have been kept relatively high.

[15] *Direction générale des prévisions statistiques agricoles.*

[16] *Institut national des statistiques et de la démographie.*

[17] 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.

as commons, the delivery of these services can be jeopardized by the privatization process that may "disrupt the chain" (Barbier, 2005). Indeed, this author shows that a misuse of pesticides -subordinated to a lack of technical advices- can induce pest resistance and productivity decline, as experienced in Thailand with the privatization of national boards in the agricultural sector. 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.

With the decline in international cotton prices, cotton revenues and the provision of public goods have shifted downwards (lower margins, negative price effect) but it has been offset by the growth of cotton areas and production for the average producer and at the national level (positive quantity effect). It can be explained by the stability of domestic cotton prices, the result of the better management of the whole sector and the better supervision of outgrower schemes. The latter was also responsible for a better access to cereal inputs, so the cotton reform has also benefited to producers with respect to grain production and food sufficiency concerns. After the reform, supply was less constrained by credit. So, we understand why the key point of the reform can be the institutional change of local groups and the establishment of the inter-profession agreement with a good representation of producers. Many interviews that we conducted with industry executives and farmer leaders and representatives have shaded some light on the importance of confidence elements in the successful results from the reform. Supply of cotton seed has increased because of more access to credit, guaranteed prices, inputs and outlets and payment dates. In brief, farmers are quite confident in cotton processors and in the commercial relationships with them. Former agrarian institutions were an important barrier for cotton production. For some experts, price was not influential in land allocation choices made by farmers[18]. So, cotton areas have grown substantially because of more confidence for cotton growers in the sector and more access to inputs.

Both entry of producers and mechanization have been responsible for the increase in pro-

[18] Above 150 CFAF, cotton supply is believed to be quite inelastic.

duction through the extension of cotton areas. According to national agricultural data, in spite of the rise of cotton areas, it was not at the expense of cereal production. Increases in land shares dedicated to cotton are correlated to a rise in total cultivated land. Indeed, some of the cotton revenues are often invested in animal-drawn farming and some credit programs have been designed for it. Average crop yield is stagnating due to limited soil fertility and limited potential of the seed varieties but the variability is even more important across producers. National data have shown that crop yield has 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, input use by unit of land has not risen but can be associated with a better long-term management of soil fertility (e.g. more manurial 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 of education, according to technical agents. So, only extensive growth factors explain aggregated cotton production: the number of producers, allocation choices and mechanization.

All these assertions have been supported by the interviews led with executives of the sector and some experts. Our empirical study is going to address these propositions, testing a set of hypotheses that we will state in the following of the paper.

2.3 Explaining cotton growth by the growth in cotton areas?

As pointed out in the previous subsection and as can be observed in figure 2 (see in the appendix), the increase in national cotton production during the reform has followed the growth of cotton areas with a quasi similar pattern. Our empirical study focuses on the determinants of the growth in cotton areas as a proxy of cotton seed production. Indeed, explaining the growth of cotton production by the extension of cotton areas is justified when crop yields are stationary. At the national level, this is verified when inspecting aggregate data (see figure 2). However, the permanent census on Burkina Faso's agriculture -using pseudo-panel data- allows us to examine what happened at the household level. The global trend is an improvement of crop yield at the household level for the same plots of land with stationary input use. With the entry of new producers and more marginal lands (less fertile), yield variability has increased with a stationary aggregate yield at the national level. We can interpret these findings as a global improvement in the quality of cotton agricultural systems management[19] with an offsetting dynamic effect from the entry of less efficient producers and less fertile lands. Hence, all other things being equal, our empirical setting that focuses on the growth of cotton areas will overestimate the cotton production growth for more marginal lands and less experienced producers while it will underestimate it for more experienced producers. However, the nature of our data (see hereafter) does not allow us to assess quantitative effects of the reform on production and on cotton areas extension. As we want to deal with the identification and the ranking of the factors that led to the growth of production through the extension of cotton areas, we will not address this issue of potentially biased estimation of cotton growth with respect to household and land types.

H1	Evolution of total farm land and change in land allocated to cotton are joint processes, and the change in total farm land is endogenous in the determination of change in cotton area
H2	Evolution of total cultivated land depends mainly on mechanization process and evolution of family labor force
H3	Ethnical background influences the evolution of total cultivated land
H4	Evolution of land shares dedicated to cotton depends more on concerns for confidence and guarantees from the cotton sector, and input and credit access, than on price concerns.
H5	There is a significant role of technical assistance in the efficiency and choices of cotton growers, that has evolved during the reform
H6	The setting of GPCs has given incentives for farmers to rise their land shares allocated to cotton

Table 1: Hypotheses to be tested

The major explanations for the growth of cotton production, given in the previous subsection will be tested on our data. We state these hypotheses in Table 1 and we will address them

[19]This has been driven by learning by doing, research and technical assistance.

when we will interpret the estimates from our regressions in Section 4.

3 Empirical strategy

A vast number of papers deal with agricultural reforms and their effects on production growth in developing countries. The empirical setting mostly consists in estimating production functions with panel or longitudinal data. Panel data are used with stochastic production frontier models in Fan (1991) to measure and separate the effects of technological change, institutional reform and input use on Chinese agricultural production growth. Concerning cotton reforms in Sub-Saharan Africa, Brambilla and Porto (2006) used repeated cross-sectional data which correspond to the reform period to measure impacts on productivity. They use difference-in-difference between cotton and maize productivities across farmers to control for farmer and crop heterogeneities. With the use of a relevant set of control variables, they are able to extract significant time dummies corresponding to the direct effect of the Zambian reform. They show that the first stage of the liberalization of the sector which has coincided with a failure of the outgrower scheme is significantly associated to the decrease in cotton productivity and then, that the second stage which has coincided to the recovery of efficiency of these schemes, is significantly associated to the increase in cotton productivities.

Our empirical methodology is departing from this literature in several aspects. First, we work with cross-sectional data and focus on the extension of cotton areas, disentangling cultivated land extension and evolution of land shares[20] dedicated to cotton. Second, we work with both subjective and objective variables to explain the driving forces that have led to the extension of cotton areas during the reform. The diversity of available data enables us to identify the determinants of cotton areas extension with cross-sectional data and a special designed questionnaire.

[20] One model of land shares dedicated to cotton is presented in the paper of Brambilla and Porto (2006) but the availability of variables is restricted and they do not use any subjective variable.

3.1 The survey design: sampling strategy and data set

We interviewed 300 households of cotton producers located in five different areas in the South and Southwest of Burkina Faso. We focus on these zones because they belong to seven provinces that produce 45 % of total national cotton production. Moreover, they are very different because some provinces are part of the traditional area of production while others are new zones of production or zones characterized by less productive patterns. Then, the cumulative production dynamics of these zones follow the same pattern as the national production[21]. In figure 4, the sampling zone is shown in bold lines (see in the appendix).

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. Then, 16 households were randomly chosen from each of the largest villages and 14 in the smallest ones. This represents 60 households per zone. 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 were randomly chosen in each stratum, proportionally to the size of the stratum. The five zones are represented in figure 5, in the appendix.

The selection of villages does not reduce representativity seriously as villages are very heterogeneous in size, ethnic composition, as well as the number and the experience of cotton growers between and within the five zones (see descriptive statistics in table 2, figure 3 in the appendix and the next section). 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 because we have only drawn our sample from lists of cotton growers but it is reasonable to think that the overestimation bias would be quite small. Moreover, we aim to qualify and identify the determinants of the observed cotton boost, so that including farmers that abandoned cotton production does not appear as a relevant issue

[21] See figure 3 in the appendix for the production trend of each visited province where we selected villages for the survey.

in addressing this purpose.

An original questionnaire was designed with recall variables and variables about the evolution of agricultural systems and economic decisions within each household. These variables were added to basic variables informing living standards, those are housing, education, health, consumption, credit, savings, crops, cattle. In addition to objective variables, 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 objective and subjective variables on the evolution of agricultural systems enables us to empirically study a dynamic process (increase in cotton areas) with cross sectional data. Detailed information on available data that we used in this paper is presented in the appendix (tables 3 and 4).

The first step in observing basic statistics from the data was to identify any selection bias in the sampling design because we have restricted the sample on a defined area. However, the sample was drawn on a stratified basis within selected villages according to the past cotton production of each household listed on GPCs' lists. In table 2, 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, average crop yields are the same in our sample with lower variance (small differences). Land distribution looks like the one of cotton zones (table 5, see in the appendix) and input use is also similar to the national average. According to technical assistants of SOFITEX, the variability in crop yields is due to the variability in mineral (chemical) and organic (manurial) fertilizers application and in input access, as confirmed by the displayed sample's basic statistics in table 2. Moreover, there is significant variability in soil fertility and experience with the cotton crop. On average, farmers apply far more nitrogen on cotton than on other crops. In figure 3, we display the production pattern of each province where we have visited at least one village. The heterogeneity of production across these provinces is significant and the cumulative one follows the national pattern.

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: Descriptive statistics of the sample

Second, we display descriptive statistics on our variables of interest, evolution of land shares dedicated to cotton and evolution of total farmland for each household during the reform, in a cross-table (table 6, see in the appendix). Two thirds of the sample corresponds to households which 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 and appears clearly in the table so that the endogeneity and simultaneity problems that we stated before seem relevant to check out and to control for if needed.

In the literature, such a correlation is often explained by the profitability-risk trade-off (Rosenzweig and Binswanger, 1993) and the risk aversion for farmers with respect to food needs when they are endowed with a low amount of land. The optimal strategy lies in a food self-sufficiency allocation choice of crops (Fafchamps, 1992; Jayne, 1994) when some markets are missing or isolated and land access is constrained. Hence, farmers endowed with small farmland areas will have less land shares allocated to cotton than those with larger plots of land or more fertile lands. In our empirical setting, it can be translated into the following assumption: the evolution of land shares dedicated to cotton is positively correlated with the evolution of total farmland. However, the reverse causality is more questionable since the allocation choice of crops compared to the access and the resources needed to farmland does not involve the same decisional process and the same kind of constraints. For crop allocation, the major constraints can arise from local institutions and credit groups, which impacts input access; and from lumpy investments with technology adoption for new cotton growers. The determinants of adoption are identified in the literature as human and social capital ones, as well as technical assistance and learning by doing plus neighboring effects (Besley and Case, 1994; Foster and Rosenzweig, 1995; Conley and Udry, 2004). Adoption is also important in the process of land extension when shifting from traditional to animal farming. Concerning access to land, other constraints may involve ethnical background, soil fertility, availability of village and family labor. Moreover, there are different dynamic processes. While allocation choice of crops can differ every year, access to land can be slower and related to social interactions within the village. To end up with, growth in land shares dedicated to cotton would not be linearly correlated to growth in total farmland as, for a sufficient amount of land, more risk-averse farmers would prefer to diversify agro-climatic and price risks among more crops.

3.2 Estimation strategy

Our estimation strategy is focusing on two variables of interest: evolution of total cultivated land and evolution of land shares dedicated to cotton. Nevertheless, these two processes are not sequential in the decisions of households, so that these two components of the growth of cotton areas need to be somehow disentangled. The data we collected on the evolution of cotton areas are discrete and ordered (see tables 6 and 7 in the appendix) according to the level of increase or decrease in total cultivated land and land shares allocated to cotton per each household. We estimate simultaneously these two variables by a bivariate Probit model. Before presenting this model, we will present the standard Probit binary model and the bivariate one. Finally, we will introduce an ordered Probit model to deal with all the available information to obtain refined results and derive marginal effects.

Consider the general simultaneous-equation model:

$$
\begin{aligned}
Y_{1i}^* &= \delta_1 + X_{1i}\beta_1 + u_{1i} && (1)\\
Y_{2i}^* &= \delta_2 + \gamma Y_{1i}^* + X_{2i}\beta_2 + u_{2i} && (2)
\end{aligned}
$$

$i = 1, 2, , N$, 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; 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 (1) and (2) 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 $\left\{S_j^k = [c_{j-1}^k, c_j^k]\right\}$, $j = 1, 2, ..., J_k; k = 1, 2$ denote such sets, with $\bigcup_j S_j^k = \Re$, $\forall k = 1, 2$ and such that $c_0^k = -\infty$, $c_J = \infty$, $\forall k$, and $c_{j-1}^k \leq c_j^k$ $\forall k, \forall j$. We observe the following ordered dependent variables: $Y_{1j} = 1$ if $Y_{1j}^* \in S_j^1$ and $Y_{2k} = 1$ if $Y_{2i}^* \in S_k^2$, $j = 1, 2, ..., J_1, k = 1, 2, ..., J_{2.}$

From the structural model (1) and (2) we have

$$
\begin{aligned}
\Pr(Y_{1i}^{*} &\in S_{j}^{1}, Y_{2i}^{*} \in S_{k}^{2}) = \Pr(Y_{1i} = j,\ Y_{2i} = k) \\
&= \Pr(c_{j-1}^{1} \leq Y_{1i}^{*} < c_{j}^{1}, c_{k-1}^{2} \leq Y_{2i}^{*} < c_{k}^{2}) \\
&= \Phi_2[c_{j}^{1} - \delta_1 - X_{1i}\beta_{1,}\theta(c_{k}^{2} - \gamma\delta_1 - \gamma X_{1i}\beta_1 - \delta_2 - X_{2i}\beta_2), \overline{\rho}] \qquad (3) \\
&\quad -\Phi_2[c_{j-1}^{1} - \delta_1 - X_{1i}\beta_{1,}\theta(c_{k}^{2} - \gamma\delta_1 - \gamma X_{1i}\beta_1 - \delta_2 - X_{2i}\beta_2), \overline{\rho}] \\
&\quad -\Phi_2[c_{j}^{1} - \delta_1 - X_{1i}\beta_{1,}\theta(c_{k-1}^{2} - \gamma\delta_1 - \gamma X_{1i}\beta_1 - \delta_2 - X_{2i}\beta_2), \overline{\rho}] \\
&\quad +\Phi_2[c_{j-1}^{1} - \delta_1 - X_{1i}\beta_{1,}\theta(c_{k-1}^{2} - \gamma\delta_1 - \gamma X_{1i}\beta_1 - \delta_2 - X_{2i}\beta_2), \overline{\rho}]
\end{aligned}
$$

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

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 identified up to a constant term).). Parameters in the system (1)-(2) are identified only if exclusion restrictions are imposed, namely at least one variable in X_{1i} should be excluded from X_{2i}. 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".

In terms of the exclusion restriction introduced above, 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. Indeed, land is never obtained commercially in cotton areas of Burkina Faso. Property rights are not formal and few informal commercial rules exist. In brief, land is the property of the village and of its chief. Land is distributed freely to any farmer who wants to grow crops but both land quality and quantity are allocated with respect to social and local political networks.

Migrant ethnic groups are likely to access less land quality and quantity than resident ethnic groups. Moreover, as the reform enabled farmers to create their own associations to access inputs, ethnical background does not matter in input access and other determinants of crop allocation. Hence, ethnical background is a good candidate for the exclusion restriction as a valid instrument of the endogenous evolution of total farmland in the determination of the evolution of land share allocated to cotton. Another candidate would be the natural land constraints, as the percentage of cropped plots with some significant slope in the same village. However, our data do not contain precise information and sufficient heterogeneity about land natural constraints, which can result as a weak instrument. To conclude, we use the ethnical dummy, "belonging to a migrant ethnic group", as the more relevant and valuable instrument in our proposed econometric setting.

Whether we consider the general model as the bivariate ordered Probit model, or the bivariate binary Probit specification, endogeneity of Y_{2i}^* as an explanatory variable in equation (2) 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 (1) 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 (1)-(2) above.

The first one is proposed by Rivers and Vuong (1988), and considers separate estimation of equations (1) and (2). 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 equation (2) together with Y_{1i} and X_{2i} as regressors. If the estimated parameter on predicted residuals is significant, then exogeneity of Y_{1i} in equation (2) is rejected. The advantage of this test 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 by bivariate (ordered) Probit and then use a Wald Test of $\gamma = 0$ in equation (2). 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 (1)-(2). 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.

4 Econometric results

We first estimate equation (2) by Maximum Likelihood binary Probit, where $Y_1 = 1$ stands for a large increase in total farmland, and $Y_2 = 1$ stands for a large increase in land share dedicated to cotton. Estimation results are presented in Table 7a, where we also report parameter estimates in the bivariate case where equation (2) is jointly estimated with equation (1) under the restriction $\gamma = 0$.

The probability of increasing land shares dedicated to cotton is positively and significantly correlated with households' concerns for guarantee of selling their crops, access to inputs, and payment date of cotton, level of technical assistance before the reform and significant increase in total farmland. There is a negative correlation with the present level of technical assistance. Cotton growers who entered the production during the reform have increased their shares more than the most experienced ones on average, except for cotton growers with one to three years of experience. However, the differences do not seem significant. When we do not account for the significant increase in total farmland (bivariate Probit case) the price concerns become positive and significant as well as the aversion for crop price variability. It is noteworthy to observe that the quality of social relationships within GPCs does not influence the decisions of households in crop allocation. All these results have to be related to hypotheses H4, H5 and H6.

As can be seen from the Rivers-Vuong exogeneity test in the single-equation case, exogeneity of total farm land increase is strongly rejected, indicating that both land changes evolve jointly, even when controlling for (exogenous) observed components. It is related to hypothesis H1.

Large increase in land shares allocated to cotton	Single-equation binary Probit	Bivariate binary Probit
Explanatory variables		
Price	.034 (.026)	.072 (.025)***
Price fluctuation	-.042 (.031)	-.062 (.030)**
Financial needs	-.015 (.024)	.002 (.023)
Food needs	-.035 (.024)	-.033 (.024)
Guarantee of selling	.098 (.030)***	.102 (.030)***
Input access	.050 (.027)*	.055 (.026)**
Animal farming access	.014 (.040)	.043 (.039)
Long term soil management	.018 (.060)	.034 (.060)
Risk diversification	-.055 (.056)	-.074 (.056)
Payment date	.158 (.074)**	.135 (.071)*
Technical advices	-.075 (.046)*	-.074 (.043)*
Technical assistance level	-.044 (.014)***	-.039 (.013)***
Past technical assistance level	.049 (.029)*	.061 (.028)**
Excellent GPC relationships	.180 (.683)	.296 (.740)
Correct GPC relationships	.007 (.676)	.078 (.732)
Unpleasant GPC relationships	-.101 (.722)	.003 (.771)
Bad GPC relationships	reference	reference
New cotton grower	.977 (.426)**	.616 (.445)
Cotton experience <3 years	-.192 (.345)	-.673 (.337)**
Cotton experience <5 years	.536 (.281)*	.098 (.263)
Cotton experience < 10 years	.332 (.195)*	.131 (.184)
Cotton grower >10 years	reference	reference
Significant increase in total farmland	1.571 (.382)***	-
Rivers-Vuong endogeneity test	-1.687 (.425)***	-
Constant	-1.060 (.685)	-.799 (.739)
Wald Chi²	70.51***	158.11***
Pseudo R^2	.177	.226
Correlation coefficient ρ	-	-0.167 (.142)
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: Estimates of a large increase in land shares allocated to cotton

In Table 7b, we present estimation results for the binary Probit model, where the definition of dependent variables is reversed: $Y_1 = 1$ for a large increase in land share dedicated to cotton, and $Y_2 = 1$ for a large increase in total farmland. A large increase here is considered to be more than 2 ha. Households are more likely to have increased their farmland by more than 2 ha during the reform when the family labor force has increased, and when agricultural systems have been improved through mechanization, which is in line with hypothesis H2. This probability is also correlated with the level of present technical assistance but not with the level of technical assistance that prevailed before the reform. We control that resident ethnic groups are more likely to have increased their farmland during the reform than migrant ones, which supports hypothesis H3 and the exclusion restriction that allows us the identification of parameters for the bivariate models.

We also control for cotton experience, showing that cotton growers which entered the growing activity of *Gossypium* during the reform are more likely to have increased their farmland than more experienced cotton growers. This has to be related with the fact that farmers already mechanized (having adopted draft animals) before the reform are more likely to have significantly increased their farmland before the reform than farmers having adopted this technology during the reform. Table 7b also shows that the likelihood of increasing farmland is undoubtedly greater for mechanized farmers than for traditional ones. Mechanization is correlated not only with cotton experience and learning-by-doing but also with technical assistance and learning from others (village effects in our setting). However, we have not included village effects in the tables because other parameters do not change[22] (except the mechanization dummies) and our conclusions remain the same. Finally, the occurrence of a large increase in land share dedicated to cotton has no significant impact on the likelihood of a significant increase in total farmland.

While increase in total farmland was tested as endogenous in the probability of increase in land share dedicated to cotton (Table 7a), the reverse does not seem to hold. Exogeneity of an increase in land share dedicated to cotton in the total farmland equation is not rejected by the Rivers-Vuong test. This indicates that the correlation between observed levels of both land

[22] A Hausman test was performed to check that there are no significant differences among the values of estimated parameters in the models of table 7a and 7b with or without village effects. These effects capture agronomic constraints, soil fertilities and other local conditions, such as local prices' variability (and local rural markets).

changes is captured by technological change, evolution of available labor force and learning by doing, which supports hypothesis H1. At this stage, our hypotheses cannot be rejected, but we need to analyze the estimation results of the ordered models to confirm these first statements.

Large increase in total farmland	Single-equation binary Probit	Bivariate binary Probit
Explanatory variables		
Family labor force	.105 (.028)***	.105 (.027)***
Village labor force	.044 (.035)	.044 (.035)
Agricultural system	.071 (.030)**	.072 (.029)**
Technical abilities	.070 (.045)	.071 (.044)
Managerial abilities	.005 (.043)	.007 (.043)
Technical assistance level	.024 (.014)*	.022 (.013)*
Past technical assistance level	-.004 (.031)	-.001 (.031)
Adopt animal farming < 10 years	.679 (.342)**	.673 (.340)**
Traditional farming	reference	reference
Already animal farming (>10 years)	1.615 (.373)***	1.597 (.372)***
Length of village residence	-.004 (.006)	-.005 (.006)
Resident ethnical group	.524 (.238)**	.549 (.228)**
New cotton grower	-.608 (.689)**	-.535 (.702)
Cotton experience <3 years	-.762 (.517)	-.819 (.590)*
Cotton experience <5 years	-.875 (.322)**	-.883 (.323)***
Cotton experience < 10 years	-.101 (.222)	-.089 (.219)
Cotton grower >10 years	reference	reference
Large increase in land share allocated to cotton	.306 (.532)	-
Rivers-Vuong endogeneity test	-.562 (.570)	-
Constant	-2.570 (.480)***	-2.446 (.431)***
Wald Chi²	93.13***	158.11***
Pseudo R^2	.348	.226
ρ (bivariate Probit)	-	-0.167 (.142)
Observations	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 a big increase in land allocated to cotton. The Wald test statistic corresponds to the null hypothesis that the parameter associated with a large increase in land share allocated to cotton is not significantly different from 0.

Table 7b: Estimates of a large increase in total farmland

We now turn to the estimation of the ordered Probit model, where dependent variables are allowed to take on more than 2 values. The change in land dedicated to cotton is classified into 6 possible modes: 1 for large decrease, 2 for moderate decrease, 3 for no change, 4 for moderate increase, and 5 for large increase. Total land change has 6 possible values: 1 for decrease, 2 for no change, 3 for less than 1 ha increase, 4 for an increase between 1 and 2 ha, 5 for an increase between 2 and 5 ha, and 6 for an increase of more than 5 ha. Using more detailed information on the extent of changes in total land and land allocation to cotton allows us to go deeper into the analysis of the determinants of the evolution of household decisions and agricultural systems.

Table 8a presents the estimation results for the model where Y_1 is associated with changes in total farmland, and Y_2 corresponds to changes in land share dedicated to cotton. Equation (2) is estimated by ordered Probit under three different procedures: single-equation ordered Probit, bivariate ordered Probit under the restriction $\gamma = 0$ (FIML I) and unconstrained bivariate ordered Probit FIML (FIML II). Parameter estimates confirm the basic results derived from Table 7a with more emphasis on the role of the concern for input access and less on the concern for guarantee of selling in deciding crop allocation. Moreover, the concern for food needs - important when the farmer is a small land owner- appears as being significantly and negatively associated to the evolution of land share dedicated to cotton. Cotton extension would be more marginal for the smallest-scale farmers.

The endogenous nature of the change in total farmland is confirmed in the ordered Probit case, where the exogeneity assumption for total farm land is again rejected by the Rivers-Vuong test. Parameter estimates obtained with the single-equation ordered Probit or the bivariate ordered Probit (FIML) II are very similar, apparently more than the bivariate ordered Probit (FIML) I in which change in total farm land is not included as an explanatory variable. The fact that cut off values are not all significantly different from 0 indicates that the restricted model (the binary Probit) is rejected in favor of the ordered Probit specification. In particular, the first and fourth cut offs are significantly different from 0 in all three cases, indicating that separation between "large decrease" and "moderate decrease", and "moderate increase" and "large increase" is relevant. On the other hand, the distinction between "no change" and "moderate increase" (cut off 3) is never significant. The correlation coefficient between unobserved random terms in the latent variable equations (1) and (2) is significant and negative (-0.291), indicating that once we control for observed components of changes in land shares allocation to cotton, then the latter is negatively correlated with the change in total farm land (simultaneity effect). As the Rivers-Vuong test rejects an exogenous evolution of total farmland in the evolution of land shares, we include the former as an explanatory variable in the estimation of the latter in the bivariate-ordered Probit (FIML) II. The Wald test for does not reject a significant evolution of total farmland in evolution of land share dedicated to cotton in this specification. This allows one to capture the endogeneity effect (0.326) in the ordered bivariate specification. It is noteworthy that endogeneity and simultaneity effects approximately offset each other, which can explain the close parameter estimates of the single-equation ordered Probit and the bivariate ordered Probit (FIML) II in Table 8a.

Evolution of land shares allocated to cotton	Single-equation Ordered Probit	Bivariate Ordered Probit (FIML)I	Bivariate Ordered Probit (FIML) II
Explanatory variables			
Price	.022 (.022)	.052 (.020)***	.022 (.021)
Price fluctuation	-.026 (.023)	-.038 (.025)	-.027 (.024)
Financial needs	-.009 (.020)	.008 (.020)	-.006 (.019)
Food needs	-.057 (.022)***	-.054 (.021)***	-.055 (.020)***
Guarantee of selling	.083 (.025)***	.091 (.025)***	.080 (.024)***
Input access	.056 (.023)**	.062 (.023)***	.054 (.022)**
Animal farming access	.013 (.034)	.030 (.034)	.009 (.033)
Long term soil management	-.074 (.057)	-.037 (.054)	-.062 (.053)
Risk diversification	-.066 (.047)	-.085 (.045)*	-.065 (.044)
Payment date	.166 (.052)***	.147 (.062)*	0.157 (.060)***
Technical advices	-.066 (.038)*	-.060 (.038)	-.058 (.036)
Technical assistance level	-.040 (.012)***	-.042 (.012)***	-.038 (.012)***
Past technical assistance level	.054 (.022)**	.065 (.027)**	.053 (.027)*
Excellent GPC relationships	-.021 (.437)	.094 (.566)	.014 (.552)
Correct GPC relationships	-.011 (.428)	.069 (.558)	.032 (.544)
Unpleasant GPC relationships	-.035 (.468)	.126 (.592)	-.001 (.577)
Bad GPC relationships	reference	reference	reference
New cotton grower	.591 (.476)	.395 (.412)	.530 (.413)
Cotton experience <3 years	-.297 (.199)	-.532 (.231)**	-.323 (.236)
Cotton experience <5 years	.338 (.216)	.175 (.203)	.296 (.204)
Cotton experience < 10 years	.009 (.174)	-.013 (.166)	.003 (.166)
Cotton grower >10 years	reference	reference	reference
Evolution of total farmland	.389 (.093)***	-	.326 (.079)***
Rivers-Vuong endogeneity test	-.417 (.119)***	-	-
Constant 1	-1.758 (.616)***	-2.650 (.672)***	-1.791 (.692)***
Constant 2	-.491 (.481)	-1.378 (.578)***	-.577 (.600)
Constant 3	.524 (.488)	-.380 (.571)	.394 (.590)
Constant 4	1.617 (.503)***	.661 (.571)	1.442 (.591)***
Wald Chi²	98.75***	64.71***	85.09***
Pseudo R²	.119	.194	.204
ρ (bivariate Probit)	-	-.004 (.080)	-.291 (.098)***
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 8a: Estimates for the evolution of land shares dedicated to cotton

Table 8b presents the estimation results for the model where Y_1 is associated with changes in land share dedicated to cotton, and Y_2 corresponds to changes in total farmland. This table also confirms the results derived from Table 7b, but with more information. First, the evolution of village labor force is now significant as a factor of land growth as well as more managerial abilities. In contrast, the level of technical assistance is no significant anymore. It should be related to the managerial ability variable that would be collinear. Here, the subjective variable - "more managerial abilities in explaining growth of farmland"- becomes significant instead of the objective one, "level of technical assistance". This leaves a room for insightful interpretations, as the role of technical assistance on farmers' managerial enhancement. Finally, the evolution of total farmland is now negatively correlated with the length of village residence. This is a control variable for the new migrants, which are awarded new land. Again, as in the case of the binary Probit specification (Table 7b), we do not reject exogeneity of land dedicated to cotton in the equation for changes in total farm land. Parameter estimates obtained with the single-equation ordered Probit or the bivariate ordered Probit (FIML) I and II are very similar. The estimated correlation coefficient in bivariate ordered Probit models estimated by FIML are naturally the same as in Table 8a. Finally, contrary to the estimation of land change for cotton, cut off estimates are significantly different from 0 in almost all cases[23]. This raises the interest of modeling changes in total farm land by more than a discrete-choice binary specification.

[23]The only exception being cut offs 1 and 2 in the single-equation ordered Probit.

Evolution of total farmland	Single-equation Ordered Probit	Bivariate Ordered Probit (FIML) I	Bivariate Ordered Probit (FIML) II
Explanatory variables			
Family labor force	.198 (.024)***	.198 (.023)***	.198 (.023)***
Village labor force	.091 (.028)***	.091 (.027)***	.093 (.027)***
Agricultural system	.118 (.024)***	.117 (.022)***	.113 (.022)***
Technical abilities	.048 (.035)	.048 (.032)	.048 (.031)
Managerial abilities	.056 (.035)*	.056 (.035)*	.064 (.034)*
Technical assistance level	.006 (.011)	.008 (.012)	.006 (.011)
Past technical assistance level	-.006 (.022)	-.007 (.024)	-.008 (.024)
Adopt animal farming < 10 years	.571 (.185)***	.571 (.193)***	.589 (.187)***
Traditional farming	reference	reference	reference
Already animal farming (>10 years)	1.071 (.270)***	1.074 (.233)***	1.114 (.226)***
Length of village residence	-.012 (.004)***	-.011 (.005)**	-.012 (.004)***
Resident ethnical group	.390 (.166)**	.386 (.155)**	.448 (.151)***
New cotton grower	-.140 (.370)**	-.147 (.373)	-.155 (.373)
Cotton experience <3 years	-.085 (.239)	-.070 (.257)*	-.054 (.256)
Cotton experience <5 years	-.158 (.207)	-.157 (.213)***	-.151 (.212)
Cotton experience < 10 years	.217 (.171)	.219 (.171)	.216 (.171)
Cotton grower >10 years	reference	reference	reference
Evolution of land shares allocated to cotton	-.036 (.190)	-	-
Rivers-Vuong endogeneity test	.032 (.203)	-	-
Constant 1	-1.042 (.838)	-0.895 (.254)***	-0.829 (.247)***
Constant 2	0.930 (833)	1.076 (.247)***	1.115 (.240)***
Constant 3	2.851 (.855)***	2.997 (.292)***	3.034 (286)***
Constant 4	3.520 (.858)***	3.666 (.306)***	3.720 (.300)***
Constant 5	4.113 (.859)***	4.259 (.323)***	4.324 (.318)***
Wald Chi^2	232.97***	64.71***	85.09***
Pseudo R^2	.292	.194	.204
ρ (bivariate Probit)	-	-0.004 (.080)	-.291 (.098)***
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 8b: Estimates for the evolution of total farmland

Our estimation results can be used to identify the components of the cotton reform that matched household concerns in deciding crop allocation and land extension. First, the institutional reform from which the GPCs were established is believed to have attracted new growers because of less opportunistic behaviors in credit repayment and more input access. Second, with the privatization of SOFITEX and the improvement of the firm's management, we know that farmers are more respected for their payment date for cotton seed sales and that guarantees of selling are more significant for cotton growers as the rating of cotton qualities is less arbitrary and, as there is more transparency within the industry and between GPCs and SOFITEX. These elements shed light on the channels through which the reform has affected the production incentives for farmers. More confidence arising from better designed local agrarian institutions and more transparent relationships with their commercial partner, as well as more access to agricultural inputs, provided farmers with incentives to enter or increase cotton in their land allocation. The more the farmers are concerned with these elements, the more they were likely to have increased their land share dedicated to cotton, once we control for their changes in farmland during the reform and for their cotton experience. Moreover, no significant differences among different experienced cotton growers can be interpreted as the fact that former cotton growers have increased their land share dedicated to cotton in the same way than farmers which entered during the reform period.

Second, no impact resulted from different qualities in the relationships within GPCs on crop allocation decisions. Indeed, the institutional reform allowed GPCs to be freely created on a co-opt basis so that every disappointed farmers is now free to switch from one GPC to another and, even to create its own group. Hence, the possibility of switching group relaxes some constraints arising from local organizations as internal relationships which can restrict access to inputs, for instance.

Third, the reform has also changed the design and the management of technical assistance, shifting from public to private sector with an involvement of cotton unions in the advisement of GPCs. While technical assistance today is limiting the increase in land share dedicated to cotton in order to prevent farmers from "all-cotton", to avoid financial insolvencies from input credit schemes and to incite them to spray some risk among different crops; it was the reverse before the reform. It is likely that former agricultural public technical services tried to push farmers doing cotton for national goals even if the financial situation of SOFITEX worsened with low repayment rate from GVs and when incentives for cotton production were low. The technical assistance is today more efficient and more adapted to cotton growing so that the positive impact should be identified on productivity (not studied here). In contrast, technical assistance is correlated to the increase in total farmland for each household. It is likely that learning externalities have fostered the adoption of animal farming (ox ploughs).

However, technical assistance had no significant role before the reform in helping farmers to increase their proficiencies and their abilities in mechanization. Moreover, the result stated in the analysis of figures from Table 8b indicates that there is a link between the present level of technical assistance and the rise of managerial abilities of farmers in the process of evolution of total farmland. So, technical assistance had a significant role in the improvement of farmers' skills and this role has evolved from 1996 up to today.

Indeed, the global farmland extension in cotton areas has to be related to the diffusion of animal farming and mechanization, as well as more rural labor inflow. There are no direct effects of the reform in these interpretations, but the new incentives arising from the reform that we made explicit before, are likely to have attracted both labor and capital to cotton areas. This indirect mechanism has been amplified by the Ivorian crisis with the arrival of hundreds of thousands farmers in South Burkina Faso. Both family and available village labor force are responsible for the observed farmland growth as subjective explanations given by households in the survey. Less labor constraints have allowed households to increase both land shares dedicated to cotton and total farmland as cotton is the most labor intensive crop. Indeed, mechanization is correlated to cotton experience and national data (INSD) inform us that the cotton areas are the most mechanized throughout the country.

All our hypotheses stated in Table 1 have been examined empirically and cannot be rejected either by binary models, or by ordered ones. Indeed, the examination of the estimates and the Rivers-Vuong tests presented in tables 7a, 7b, 8a and 8b supports the extension of cotton areas as a joint process of increasing both land shares dedicated to cotton and total farmland, where the latter is endogenous in the determination of the change in cotton areas (H1). While total farmland change depends largely on the evolution of familial labor force and the process of mechanization with constraints arising from ethnical background (H2 and H3), the change in land shares dedicated to cotton is driven by confidence effects and guarantees stemming from the sector as well as concerns for input access (H4). There is an associated significant role for technical assistance in restraining the growth of land shares dedicated to cotton to control for agro-climatic and financial risks (H5). Finally, the setting of GPCs has allowed more farmers to enter cotton growing (H6), with less institutional constraints; This put some emphasis on the role played by the institutional design on the new production incentives led by the reform.

We also wish to compare the performance of our models in terms of goodness of fit, by evaluating in particular the proportion of correct predictions. In Tables 9 and 10 (see in the appendix), we present goodness of fit statistics for the binary and ordered models. For binary models, the predictive power is very reasonable for all models and quite similar for the estimation of large increase in land share dedicated to cotton (correct predictions between 59 and 78 percent). However, the bivariate Probit model is performing better for the estimation of significant increase in total farmland[24]. Table 10 shows that ordered models are quite equivalent in their predictive power, whatever criterion is chosen. We use three different criteria to deal with the predictive power of ordered models: the estimated probability corresponding to the observed categorical value of each independent variable is above 50 %, the estimated probability is the maximum of all estimated probabilities for all categorical values, and the estimated probability is above the sample probability of appearance. For the evolution of land share dedicated to cotton, all models predict between 20 to 25 % of observations according to the first criterion (the stricter one), around 45 % for the second one and around 70 % for the third one. For the evolution of total farmland, more than 50 % of observations are well explained according to the first criterion, more than 60 % according to the second one and 84 % for the third one. In some respects, these figures put forward the idea that our models can be use as predictive tools.

In Tables 11 and 12 (see the appendix), we display marginal effects of explanatory variables computed for the single-equation ordered Probit models of land share dedicated to cotton and the evolution of total farmland, respectively.

Concerning the evolution of land share dedicated to cotton, we see that the concern for food needs only to play a role in limiting the trend of increasing cotton in crop allocations as well as the concern for technical advices while it was the reverse for guarantee of selling, input access and payment date concerns. The level of present technical assistance also limits the scope of increasing land shares dedicated to cotton while in the past, the effect was concentrated on the big increase regime. For each regime, the strongest effect comes from the concern for payment

[24]More than 90 % correct predictions compared with 67 % for the single-equation Probit model.

date, then the concern for guarantee of selling and equivalently concerns for input access, technical advices, food needs, and levels of technical assistance. Evolution of total farmland is correlated with the likelihood of having experienced a big increase in the share, and negatively correlated with the other regimes. For the role of cotton experience, there are no significant differences between experienced and less experienced cotton growers in regimes of increase in the land share allocated to cotton. In contrast, new cotton growers are less likely to have their land share stagnated or decreased as they entered production recently.

Concerning the evolution of total farmland, as expected, the increase in both family and village labor force availability is correlated with regimes of increases in total farmland as well as the evolution of agricultural systems. The family labor force is the most important factor, followed by the change in agricultural system and village labor force. Farmers who adopted animal farming during the reform are more likely to have increased their farmland but less than farmers who adopted it before the reform. However, for farmers who adopted animal farming recently, we should add to the dummy variable of mechanization, the subjective one of change in agricultural system so that, in total, it is likely that some recently mechanized farmers have increased their farmland more than already mechanized ones. Cotton groups belonging to resident ethnical groups are more likely to have increased their farmland than those who belong to migrant ethnical groups. This effect is however less strong than the one of mechanization or than the increase in labor availability.

Less labor and institutional constraints, as well as more access to capital -agricultural inputs and mechanization- with technology adoption have allowed farmers to increase their cotton areas. In brief, cotton has oriented labor force and mechanization to rural areas, thus participating to the extensive growth of agriculture, with a growth of households' land share allocated to cotton led by new incentives coming from the cotton reform. However, the situation seems much unsecured because of the low ability of cotton firms to pay and finance cotton growing through contract farming and outgrower schemes in a very low world price environment.

5 Conclusion

The empirical study of the determinants of the extension of cotton areas in Burkina Faso highlights the role played by direct incentives led by the reform in crop allocation decisions made by households: confidence effects and input access. These factors are acknowledged to be the positive consequences from the cotton reform, with a new institutional design both for producers and for the organization of the industry. While new institutions of producers allowed them to reach at some substantial bargaining power and at more efficient local organizations for outgrower schemes to be established, the new organization of the industry arising from the privatization process was responsible for a more transparent and coordinated system, with a significant empowerment of producers. This gave rise to greater financial commitments from banks and cotton firms and more available inputs and credit for producers, facing less institutional constraints and more production incentives[25].

While the new institutional design allowed producers to benefit from the privatization process, being responsible for a growing number of responsibilities, the cotton boost has to be associated to other externalities, as indirect consequences from the cotton reform: mechanization, rise of available labor force in cotton areas, technological and managerial improvements -learning externalities (technical assistance and neighboring effects) and learning-by-doing- which participated to the global agricultural extension growth and to the setting of a more professional farming. However, the channels whereby the reform has fostered these externalities remain unclear, even if the new production incentives are likely to have attracted capital and labor to cotton areas with more efficient extension services to make farmers able to adopt new technologies and to better manage their organizations.

However, the spectrum of new difficulties faced by the Burkinan cotton sector fronting declining world cotton prices and increasing input prices unveils that this cotton boost is not sustainable in the long-run if cotton firms and banks are not able to recover their loans anymore. New challenges involve the development of new technologies to improve productivities, new marketing strategies to build a strong reputation of Burkina Faso's cotton quality and to access

[25] See Kaminski (2007a) for the formalization of the impact of the institutional design on production incentives for farmers.

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. 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 boost this year[26]. Moreover, the inter-professional partnership has agreed upon a strong reduction in the price of cotton paid to farmers for the new crop season. The future of the Burkinan cotton sector now appears very uncertain.

The dependence of the Burkina Faso economy on its cotton sector is a substantial issue as no significant alternatives appears to be able to constitute a relevant substitute solution for farmers so that the cotton boost is not a panacea in poverty reduction strategies. It becomes urgent to find other solutions for agriculture with the involvement of research and investors to develop cash crop markets and to improve food security. Finally, there is a need to develop the management and implementation of soil conservation schemes -organic applications (manurial fertilizers), fallowing, new soil techniques, crop associations- and the struggle against desertification, with an adequate control of agricultural input use.

This paper has focused on production issues and the role of the cotton reform in the observed cotton boost. However, we may wonder whether this cotton boost has been associated to poverty reduction and improved living standards and how farmers have perceived it. This analysis is left for future research.

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6 Appendix

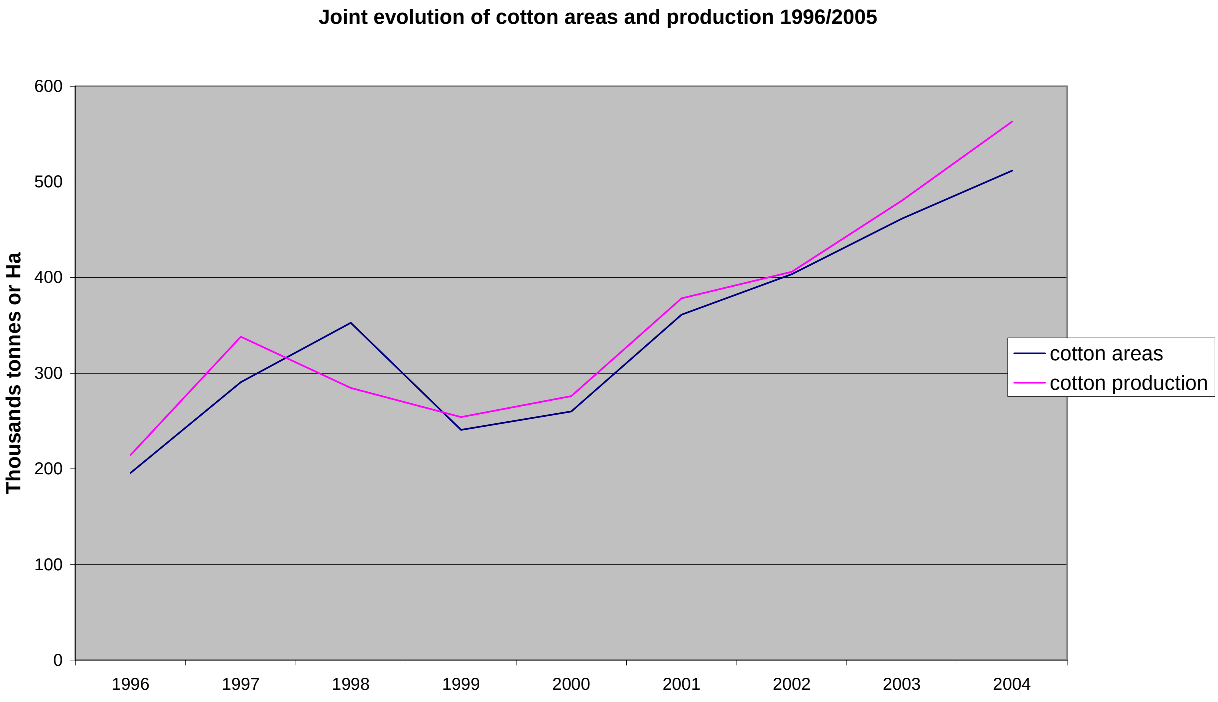

Figure 2: Cotton areas and production during the reform

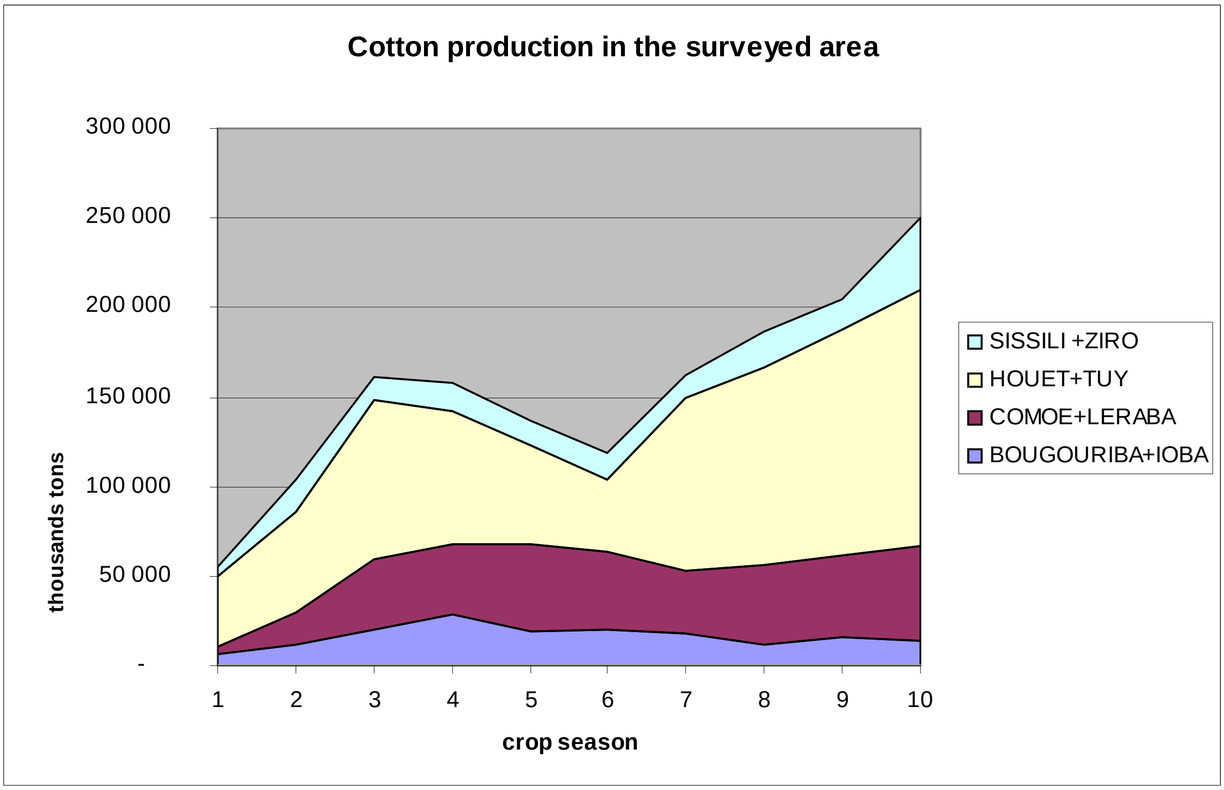

Figure 3: Cumulative and regional production patterns between 1995 and 2005

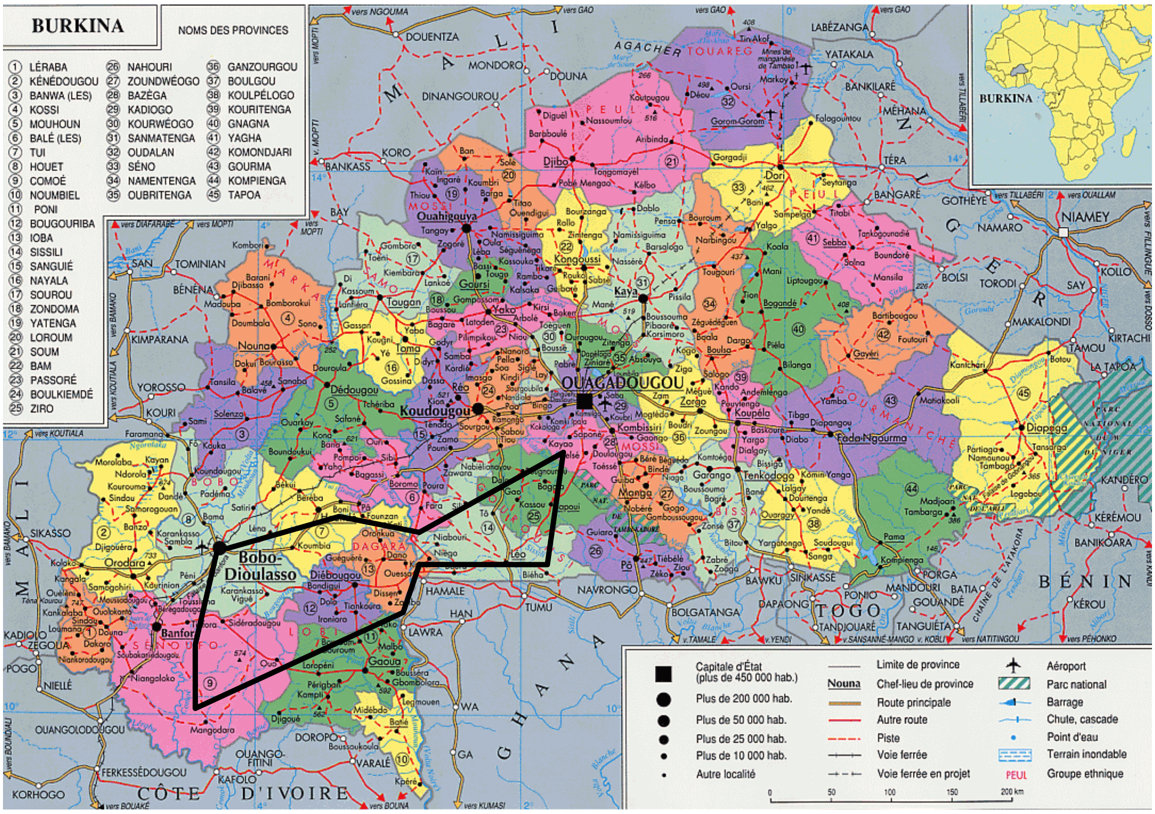

Figure 4: Sampling area

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

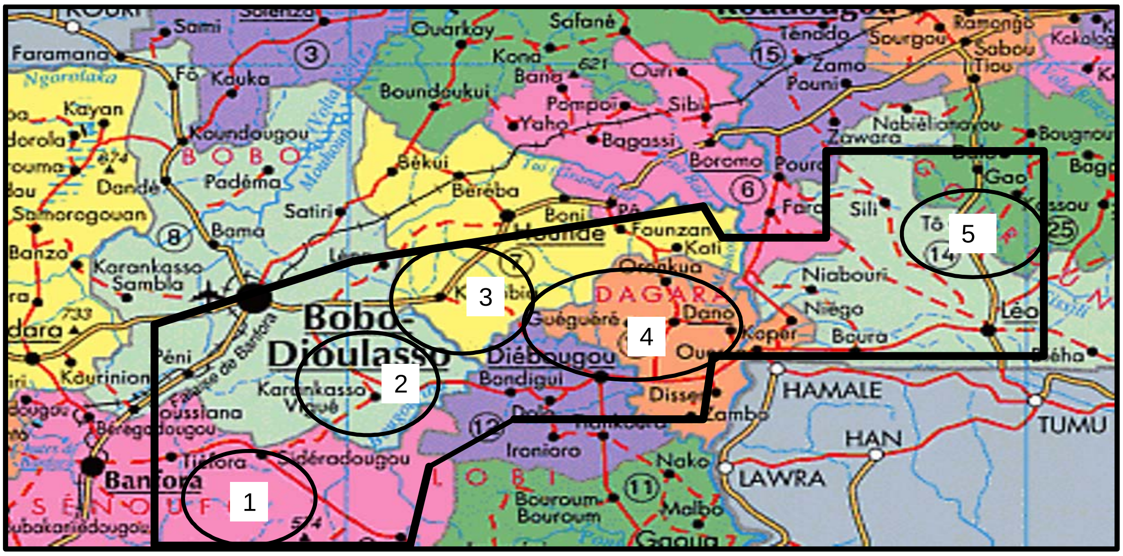

Figure 5: Sampling map

Variable name	Description	Mean	SE
Length of village residence	Length of village residence for the household in years	19.45	15.29
Technical assistance level	Number of visits of technical agents last year	2.95	5.69
Past technical assistance level	Number of visits of technical agents 10 years ago	1.95	2.84
Family labor force	Importance of increase in family labor force during the reform to explain farmland growth*	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
Price	Importance of prices in deciding crop allocation	4.12	3.81
Price fluctuation	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
Animal farming access	Importance of access to animal drawn farming systems in deciding crop allocation	1	2.42
Long term soil management	Importance of long term land management in deciding crop allocation	0.37	1.46
Risk diversification	Importance of risk diversification strategies in deciding crop allocation	0.64	1.96
Payment date	Importance of dates of crop payments in deciding crop allocation	0.36	1.49
Trust	Importance of trust in trade relationships in deciding crop allocation	0.38	1.49
Family pressure	Importance of family influences in deciding crop allocation	0.65	1.93
Technical advices	Importance of advices from technical agents in deciding crop allocation	0.91	2.13
Cooperative	Importance of advices from the cooperative in deciding crop allocation	0.59	1.87

* All the variables described from here to the end of this table are taking values on a scale of [0, 10].

Table 3: Description of continuous 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 ethnical group	Dummy variable on the ethnical group type of the household,	
	=1 if the household belongs to a resident (in contrast to a migrant) ethnical 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: Description of categorical, ordered and dummy variables

Present total farmland	Less than 2 ha	Between 2 and 5 ha	Between 5 and 10 ha	Between 10 and 15 ha	More than 15 ha	Total number of households
Total farmland (over the 10 last years)						
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		2	8	8	4	22
Has increased > 5 ha		1	6	7	8	22
Total number of households	16	128	100	37	19	300

Table 5: Evolution of total cultivated land vs present farmland

Evolution of land share allocated to cotton	Much increased	Slightly increased	Remained constant	Slightly decreased	Much decreased	Total number of households
Evolution of farm Land						
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 6: Evolution of total cultivated land vs evolution of land share allocated to cotton

Variable	Outcome	Sample frequency (proportion)	Single-equation Probit	Bivariate Probit
			% Correct predictions	
Big increase in land share dedicated to cotton	1= Yes	0.423	0.591	0.598
	0 = No	0.577	0.786	0.751
	Total	-	0.704	0.686
Significant increase in total farmland	1 = Yes	0.273	0.585	0.634
	0 = No	0.727	0.674	0.917
	Total	-	0.650	0.840
Joint processes: [Big increase in land share dedicated to cotton, significant increase in total farmland]	[1,1]	0.15	-	0.2
	[1,0]	0.273	-	0.280
	[0,1]	0.123	-	0.189
	[0,0]	0.453	-	0.618
	Total	-	-	0.410

Note: the percentage of correct predictions is the proportion of observations (for each mode) corresponding to the criterion of a correct prediction by the model, here when the estimated probability is above 0.5.

Table 9: Goodness of fit of binary Probit models

Variable	Outcome	Sample frequency (proportion)	Single-equation Ordered Probit	Bivariate Ordered Probit (FIML) I	Bivariate Ordered Probit (FIML) II
			% correct predictions		
Evolution of land share dedicated to cotton	1= Large decrease	0.003	0	0	0
			0	0	0
			1	1	1
	2= Decrease	0.057	0	0	0
			0	0	0
			0.706	0.765	0.647
	3= No change	0.183	0	0	0
			0.218	0.2	0.2
			0.836	0.8	0.855
	4= Increase	0.333	0	0	0
			0.4	0.34	0.35
			0.75	0.72	0.68
	5= Large increase	0.423	0.567	0.488	0.528
			0.701	0.732	0.701
			0.677	0.669	0.646
	Total	-	0.240	0.206	0.223
			0.470	0.459	0.450
			0.732	0.716	0.696
Evolution of total farmland	1= Decrease	0.043	0	0	0
			0	0	0
			0.769	0.769	0.769
	2= No change	0.283	0.894	0.894	0.871
			0.941	0.929	0.906
			1	1	1
	3= increase by less than 1 ha	0.4	0.65	0.642	0.642
			0.817	0.825	0.792
			0.808	0.808	0.8
	4= increase between 1 and 2 ha	0.127	0	0	0
			0	0	0
			0.658	0.632	0.658
	5= increase between 2 and 5 ha	0.073	0	0	0
			0	0	0
			0.818	0.818	0.818
	6= increase by more than 5 ha	0.073	0.227	0.227	0.227
			0.409	0.409	0.409
			0.818	0.818	0.818
	Total	-	0.530	0.526	0.520
			0.623	0.623	0.603
			0.842	0.839	0.839

Notes: the percentage of correct prediction is the proportion of observations (for each mode) corresponding to the criteria of a correct prediction by the model. There are three criteria for ordered models; they are respectively when the estimated probability is above 0.5, when this is the maximum value of all estimated probabilities, and when it is above the sample appearance probability. Obviously, these three respective criteria are less and less strict (for most cases).

Table 10: Predictive power of ordered models

Evolution of land shares allocated to cotton	Big decrease	Decrease	Stagnation	Increase	Big increase
Explanatory variables					
Price	-.066 (.08)	-1.485 (1.5)	-4.608 (4.63)	-2.425 (2.48)	8.583 (8.52)
Price fluctuation	.076 (.1)	1.716 (1.57)	5.327 (4.71)	2.803 (2.57)	-9.922 (8.73)
Financial needs	.027 (.06)	.606 (1.35)	1.879 (4.14)	.989 (2.19)	-3.500 (7.7)
Food needs	.169 (.2)	3.827 (1.84)**	11.878 (4.65)**	6.250 (2.61)**	-22.124 (8.34)***
Guarantee of selling	-.247 (.27)	-5.592 (2.13)***	-17.355 (5.35)***	-9.132 (3.55)***	32.326 (9.55)***
Input access	-.164 (.19)	-3.739 (1.72)**	-11.603 (4.97)**	6.206 (2.96)**	21.613 (8.94)**
Animal farming access	-.039 (.11)	-.878 (2.32)	-2.726 (7.04)	-1.434 (3.71)	5.078 (13.13)
Long term soil management	.218 (.28)	4.953 (4.09)	15.372 (12.04)	8.089 (6.35)	-28.632 (22.06)
Risk diversification	.196 (.23)	4.450 (3.36)	13.812 (9.97)	7.268 (5.39)	-25.726 (18.26)
Payment date	-.492 (.54)	-11.154 (4.36)**	-34.615 (11.73)***	-18.215 (7.04)***	64.475 (20.29)***
Technical advices	.195 (.24)	4.430 (2.9)	13.748 (7.96)*	7.235 (4.36)*	-25.608 (14.65)*
Technical assistance level	.118 (.12)	2.680 (1.02)***	8.316 (2.55)***	4.376 (1.65)***	-15.490 (4.48)***
Past technical assistance level	-.160 (.18)	-3.639 (1.78)**	-11.293 (4.77)**	-5.947 (2.68)**	21.036 (8.51)**
Excellent GPC relationships	.061 (1.32)	1.382	4.270 (91.18)	2.222 (46.86)	-7.934 (169.03)
Correct GPC relationships	.032 (1.26)	.723	2.244 (88.98)	1.183 (46.99)	-4.183 (165.87)
Unpleasant GPC relationships	.107 (1.51)	2.382	7.255 (98.65)	3.627 (46.75)	-13.371 (179.93)
Bad GPC relationships	reference	reference	reference	reference	reference
New cotton grower	-.821 (.95)	-24.200 (11.14)**	-100.456 (61.86)*	-106.683 (111.1)	232.160 (280.21)
Cotton experience <3 years	1.308 (1.78)	24.706 (19.84)	64.566 (45.81)	19.893 (8.87)**	-110.474 (70.26)
Cotton experience <5 years	-.711 (.84)	-18.309 (9.89)*	65.182 (38.71)*	-49.118 (39.45)	133.320 (85.59)
Cotton experience < 10 years	-.025 (.05)	-.571 (11.59)	-1.778 (36.17)	-0.943 (19.37)	3.317 (67.73)
Cotton grower >10 years	reference	reference	reference	reference	reference
Evolution of total farmland	-1.148 (1.29)	-26.033 (8.01)***	-80.792 (21)***	-42.514 (15.09)***	150.488 (36.06)***
Observations	300	300	300	300	300

Note: robust standard errors in parentheses, * is significant at 10 %, ** is significant at 5 %, *** is significant at 1 %.

Table 11: Marginal effects (in 10^{-3}) for the ordered Probit model of the evolution land share dedicated to cotton

Evolution of total farmland	Decrease	Stagnation	+ [0,1] ha	+ [1, 2] ha	+ [2, 5] ha	+ > 5 ha
Explanatory variables						
Family labor force	-1.583 (.79)**	-54.653 (7)***	12.914 (7.18)*	26.694 (4.79)***	11.728 (2.93)***	4.901 (1.8)***
Village labor force	-.734 (.39)*	-25.330 (7.68)***	5.985 (3.86)	12.372 (4.09)***	5.435 (1.83)***	2.217 (.92)**
Agricultural system	-.940 (.51)*	-32.430 (6.82)***	7.663 (4.43)*	15.840 (3.87)***	6.959 (2.19)***	2.908 (1.15)**
Technical abilities	-.386 (.33)	-13.330 (9.66)	3.150 (2.74)	6.510 (4.89)	2.860 (2.17)	1.195 (.98)
Managerial abilities	-.451 (.34)	-15.552 (9.55)*	3.675 (3.08)	7.596 (4.66)*	3.337 (2.16)	1.394 (.99)
Technical assistance level	-.052 (.09)	-1.810 (3.07)	.428 (.76)	.884 (1.51)	.388 (.67)	.162 (.27)
Past technical assistance level	-.049 (.18)	1.678 (6.08)	-.392 (1.44)	-.819 (2.99)	-.36 (1.32)	-.150 (.54)
Adopt animal farming < 10 years	-5.880 (3.55)*	-163.263 (54.47)***	52.043 (27.59)*	72.788 (25.08)***	31.291 (12.43)**	13.019 (6.02)**
Traditional farming	reference	reference	reference	reference	reference	reference
Already animal farming (>10 years)	-4.730 (2.33)**	-218.893 (37.07)***	-87.480 (66.99)	152.488 (40.63)***	96.618 (37.2)***	61.997 (31.35)**
Length of village residence	.092 (.06)*	3.174 (1.15)***	-.75 (.47)	-1.550 (.6)***	-.681 (.3)**	-.285 (.14)**
Resident ethnical group	-3.636 (2.76)	-11.054 (48.43)**	32.425 (20.18)*	50.827 (22.67)**	21.885 (10.99)**	9.038 (5.14)*
New cotton grower	1.348 (4.24)	40.515 (111.67)	-13.399 (46.59)	-17.989 (45.09)	-7.499 (17.93)	-2.976 (6.75)
Cotton experience <3 years	0.751 (2.33)	24.103 (69.33)	-6.935 (23.19)	-11.194 (30.87)	-4.781 (12.83)	-1.943 (5.07)
Cotton experience <5 years	1.483 (2.44)	45.314 (61.85)	-14.412 (24.37)	-20.389 (26.32)	-8.568 (10.58)	-3.429 (4.07)
Cotton experience < 10 years	-1.501 (1.19)	-57.2385 (43.12)	8.276 (7.86)	30.275 (24.3)	14.007 (12.42)	6.181 (5.82)
Cotton grower >10 years	reference	reference	reference	reference	reference	reference
Evolution of land share allocated to cotton	0.289 (1.53)	9.986 (52.55)	-2.360 (12.46)	-4.878 (25.66)	-2.143 (11.32)	-.895 (4.72)
Observations	300	300	300	300	300	300

Note: robust standard errors are in parentheses, * is significant at 10 %, ** is significant at 5 %, *** is significant at 1 %.

Table 12: Marginal effects (in 10^{-3}) for the ordered Probit model of the evolution of total farmland

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