THE ELUSIVE QUEST FOR SUPPLY RESPONSE TO CASH-CROP MARKET REFORMS IN SUB-SAHARAN AFRICA: THE CASE OF COTTON

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Abstract: Empirical evidence from comparative studies on the impact of structural adjustment on Sub-Saharan African agricultural performance remains largely inconclusive. To illuminate this debate, we estimate the impact of liberalization on productivity, acreage and production while controlling for potential sources of supply response variation, notably the pace and depth of reforms, the nature of pre-reform policies and weather. We find that the impact of reforms varied both with the degree of liberalization and pre-reform policies: the clear positive impact on productivity was stronger in East and Southern Africa, especially where competition increased most. The impact on cultivated areas and production is less clear.

Key words: Sub-Saharan Africa, Agriculture, Structural Adjustment, Cotton, Climate

JEL codes: Q13, Q18, C23, L12, L32

1. INTRODUCTION

While there is widespread agreement that cash-crop markets in Sub-Saharan Africa (SSA) have been significantly liberalized since the early 1990s (Anderson and Masters, 2009; Delpeuch and Poulton, 2011), the effects of such reforms largely remain elusive. The impact of structural adjustment on agricultural performance has been widely researched. Positive supply and productivity responses have been identified in Asia (e.g. Rozelle and Swinnen, 2004) as well as, to a lesser extent and with a lag, in some of the European transition countries (e.g. Swinnen and Vranken, 2010). In contrast, in SSA, if any, the impact of reforms is found to have varied in direction and magnitude. No cross-cutting conclusions emerge from comparative studies in SSA, except for the timidity of impacts (e.g. Kheralla *et al.*, 2002; Akiyama *et al.*, 2003).

Reviewing the literature on agricultural transition in developing countries (DCs) and on agricultural productivity in Africa, we identified four potential sources of supply and productivity response variation, which could conceal overarching trends: the depth of reforms and resulting post-reform market organization, the nature of pre-reform policies, the institutional requirements of production processes and external forces such as weather or conflict.

The relatively limited scope of reforms, or their imperfect implementation, has long been identified as one potential explanation for their overall timid impact in DCs (Krueger *et al.*, 1988). Delpeuch and Leblois (2013) however offer evidence on the fact that reforms in the cotton sectors of SSA have not all been of limited scope and that they have instead brought about changes in market organization that vary widely in scope both across countries and over time. A long-term perspective and precise knowledge of the nature of post-reform market organization hence seem to be necessary to capture the effects of reforms.

Second, there is growing evidence that pre-reform state control of cash crop markets also varied in nature across countries and crops as well as over time, with policies ranging from direct support to taxation, depending on governments' objectives and on the level of the world price for different commodities (Kasara, 2007; Anderson and Masters, 2009; Delpeuch and Poulton, 2011). The nature of pre-reform agricultural policies has been identified as a key determinant of supply response in Asia (Rozelle and Swinnen, 2004). There are thus reasons to expect the impact of reforms in SSA to be crop- and country-specific and to have varied depending on the time of their introduction.

Third, the imperfect nature of inputs and credit markets in Africa and the difficulty to enforce contracts, imply that the impact of reforms could vary depending on the size of input requirements for different crops. Indeed, when production requires the use of costly inputs and interlocking of input and output markets is necessary, introducing competition not only affects the prices received by farmers, but also the sustainability of input-credit schemes (Dorward et al., 2004; Delpeuch and Vandeplas, 2012).

Finally, many external factors influence performance post-reform, among which, variations in world market conditions, domestic macro-economic policies, conflicts and, most importantly, weather conditions (Meerman, 1997).[1] With a few exceptions (e.g. Brambilla and Porto, 2011and Kaminski *et al.,* 2011), these external factors – in particular weather conditions – are rarely formally accounted for in studies of agricultural transition in SSA.

This paper thus aims to illuminate long-standing debates about the impact of structural adjustment in SSA agriculture by adopting a novel quantitative, sectoral and long-term approach, in which we consider all of the above-mentioned sources of potential supply response variation. The methodology chosen is deliberately quantitative and comparative to complement an existing literature that is largely qualitative (for example Tschirley et al., 2009) and case-studies based (for example Brambilla and Porto, 2011 or Kaminski et al., 2011). The comparative nature of this paper places the analysis at the level of national data: it abstracts from within country and household-specific dynamics to analyse the broader picture.

The cotton sector is the focus of this paper because of its particularly interesting institutional history which has put the sector at the centre of a passionate political economy debate. Cotton remains at the core of vivid policy discussions, both around domestic market organization and the role of international financial institutions in the reform processes, and, on the international scene, around rich countries' subsidies (Moseley and Gray, 2008; Delpeuch, 2011). A large number of countries in SSA have had very similar cotton market organizations for decades (a legacy of colonial policies) but have chosen reform options that differ in several dimensions. This situation offers a privileged set-up for examining variations in post-reform performance and identifying the reasons for those variations. The policy implications of our results should be of widespread interest in SSA: cotton is the main source of cash revenue for more than two millions rural households and a major source of foreign exchange for about fifteen countries on the continent (Tschirley *et al.*, 2009).

Our estimation strategy builds on two new datasets. First, we use the market organization indices compiled in a companion paper (Delpeuch and Leblois, 2013) to inform the timing of reforms and characterize the nature of post-reform market organization and pre-reform policies. Second, we construct precise indices of weather conditions at the level of national cotton cultivation zones, using the Climatic Research Unit of the University of East Anglia (2011) monthly weather data. Most of the other traditional determinants of the supply-function are controlled for by country and year fixed-effects in a reduced-form model. The model is estimated statically (OLS) and dynamically (GMM).

We find that yields were positively impacted by reforms, but the magnitude of this effect varies significantly, with at least twice as much impact in countries where reforms led to strong competition than in those where competition remained constrained post-reform.

The impact on production, on the contrary, appears to be significantly positive in countries where reforms led to the establishment of regulated sectors with very little competition due to increases in the area under cultivation. Where stronger competition was introduced, we find that the gains in land productivity did not materialize into significant production growth. We attribute the lack of supply response in these countries to the selection effect described by Brambilla and Porto (2011): the introduction of strong competition would have pushed the least efficient farmers out of the sector, hence causing average yields to increase but production to shrink because of declining area under cultivation. Additional investigation into household-level data would help confirm these findings which are in line with the observations of a number of case studies referred to in this paper.

These contrasted results confirm the necessity to distinguish between different reform types and pre-reform policies.

The remaining of this paper is organized as follows. In section 2 we describe the reforms undertaken in SSA cotton sectors and the expected relation between market organization and performance. We also display graphical evidence on the empirical relation between market organization and performance. In section 3 we describe the estimation strategy and its theoretical underpinnings. Section 4 describes our variables and data sources. Section 5 discusses and addresses endogeneity issues. Section 6 discusses results and robustness checks. Section 7 concludes.

2. REFORMS AND PERFORMANCE

(a) Reforms in SSA cotton sectors

Traditionally, most African cotton sectors have been organized around state-owned enterprises enjoying both a monopsony for seed cotton purchase and a monopoly for cotton input sale. In addition, prices were fixed by governments or administrative bodies, and sales were guaranteed for producers. In some countries, the 'parastatals' or 'boards' also supplied services related to production and marketing including research dissemination, transport, ginning and exporting. Notably in ex-French colonies, these companies sometimes even provided public services in the rural cotton areas. Following recommendations by the World Bank and the International Monetary Fund, SSA cotton sectors have however seen their share of reforms starting in the mid-1980s in ESA and Anglophone WCA and since the mid-1990s in Francophone WCA.

The nature of the changes in market organization brought about by these reforms has widely varied across regions, ranging from the introduction of strong competition following far-reaching market and price liberalizations, to only marginal adjustments. While an increasing number of markets have become competitive, in 2008, 50 percent of production in SSA still originated from markets with pan-seasonally and pan-territorially fixed prices (Delpeuch and Leblois, 2013). Schematically, former British colonies have implemented far-reaching reforms up to the mid-1990s and former French colonies in WCA have introduced more modest reforms, if any, starting in the mid 1990s. What follows briefly illustrates how the degree of competition has been affected as a result of both private sector responses to reform and introduction of new regulations. Delpeuch and Leblois (2013) describe these reform processes and resulting evolutions in market structure into more details.

Markets were thoroughly liberalized in Nigeria in 1986; Kenya in 1993; Malawi; Uganda, Zambia, Zimbabwe in 1994 and Tanzania in 1995. However, the degree of competition has also fluctuated, among these countries and over time. In Zambia, for example, the level of competition is said to have declined during the first half of the 2000s when the two biggest ginning companies began to cooperate in an attempt to fight side- selling (Brambilla and Porto, 2011). In Zimbabwe and in Uganda, limits to the degree of competition were imposed by the state with the aim of containing the detrimental effect of competition on the provision of inputs and extension: in Zimbabwe legal requirements with respect to inputs provision by cotton ginners were enforced in 2006 effectively limiting the number of companies authorized to operate in the ginning sector and, in Uganda, regional monopsony rights were established between 2003 and 2008.

The reforms implemented in Benin (1995), Burkina Faso (2004), Côte d'Ivoire (1994), and Togo (2000) have not given rise to competitive but 'hybrid' markets characterized by regulation and mixed private-public ownership. Where private companies are allowed to operate in addition to, or *in lieu* of the parastatals, they have been granted regional monopsony rights. Alternatively, ginning firms are administratively attributed purchasing quotas (with indications on where to source). What is more, prices remain administratively fixed pan-territorially and pan-seasonally everywhere. The price fixation method has however been revised in some countries. Instead of being decided unilaterally by the state or the parastatals, prices are increasingly determined by inter-professional bodies, which include representatives of farmers, ginners, transporters and input providers.

(b) Expected relation

Market organization and institutional arrangements are believed to influence performance through a number of linkages. Some of these linkages are common to any sector: competition should improve the share of the world price received by farmers, and, in turn, positively impact the area under cultivation and the amount of effort and inputs that farmers put into cotton cultivation, with positive effects on yields. In addition, if economies of scale are not suppressed and new transaction costs not introduced, competition should create cost minimization incentives and increase the benefits to be shared with farmers. As underlined by Baffes (2007), privatization should also minimize soft budget constraints, excessive employment or political interference in management.

The relation between market organization and performance, however, is likely to be affected by the conjunction of three characteristics of cotton cultivation in Africa: input requirements, credit and liquidity constraints and limited contract enforcement. Cotton cultivation indeed uses costly inputs (fertilizers and pesticides). Farmers however face strong cash constraints as credit markets are quasi non-existent in rural areas. As a result, most production in SSA occurs through interlinked transactions, whereby ginning societies lend inputs to farmers in return for supplies of primary produce.[2]

In this context, the capacity of a country to produce and export cotton is highly dependent on the sustainability and the scale of input-credit schemes. The sustainability of these schemes in turns depends on the capacity of farmers and ginning companies to enforce interlinking contracts (Dorward *et al.*, 2004). Delpeuch and Vandeplas (2012) formally show that because contract enforcement mechanisms are at best imperfect in many African countries, the sustainability of interlinking is highly influenced by market organization. The higher the degree of competition, the more farmers have the possibility to 'side-sell', that is, to sell their cotton to other higher-bidding buyers at harvest, instead of to the company that has pre-financed their inputs – unless sufficiently high reputation costs can be imposed on defaulting farmers. On the one hand, this magnifies the effect of competition on producer prices, but on the other, it reduces the sustainability of contracts if the company that has pre-financed the inputs cannot afford to pay a premium discouraging side-selling. The major advantage of a monopolistic or moderately competitive market organization is thus to facilitate the sustainability of input provision on credit.[3]

In addition, farmers' incentives to participate in the input-credit schemes are not only affected by price levels but also by price risk. Pan-seasonal price fixation offers farmers hedging against intra-seasonal price variations (Leblois et al., 2013). Price liberalization therefore also has bearing on input consumption intensity and farmers' participation in cotton cultivation where inputs are a pre-requisite.

It is difficult to predict, a priori, the net impact of market organisation on incentives to produce as the extent to which producer prices increase with competition, and the value of the benefits of price fixation which are lost with liberalization are likely to be country- or even household-specific depending on households' outside options and resources.

In addition, as price liberalization removes government intervention in price-setting, the nature of pre-reform intervention greatly matters: if farmers were taxed before reforms, liberalizing prices will improve production incentives. However, if they were being subsidized, production incentives will be weakened.

There is widespread agreement that, on average, African governments have largely taxed exportable cash crops (e.g. Krueger, *et al*., 1988; Anderson and Masters, 2009; Bates and Block, 2009). The magnitude and the direction of state price intervention in cotton markets, however, have varied according to the world price and the objectives of governments (Delpeuch and Poulton, 2011). The countercyclical nature of support to the agricultural sector is believed to be a common feature of agricultural policies (e.g. Gawande and Krishna, 2003; Swinnen, 2010). One explanation is rent maximization: if cotton is governments' major source of income, it is rational for them to subsidize their cotton sectors at times of low world prices to avoid production disruption. Another possible explanation is that government preferences exhibit loss aversion (Tovar, 2009) and therefore tend to protect the sectors where profitability is on the decline.

The link between market structure and productivity is also ambivalent. Indeed yields will be affected by changes in prices but also by the sustainability and scale of the input credit system post-reform. As noted by Brambilla and Porto (2011), while inputs allow farmers to increase their productivity; as the scale of farmers who receive inputs increases (hence boosting production), more marginal land and less experienced farmers are dragged into production, hence potentially driving down average yields.

In summary, liberalization is expected to influence production incentives positively unless input-credit schemes collapse and/or the benefits of introducing competition are offset by the elimination of state support or the creation of new inefficiencies for example through the loss of economies of scale. The expected relation between market organization and yields is also subject to context specificities. One the one hand, competition should boost efficiency by providing better incentives for investing in productivity-enhancing practices both at farm and ginning levels as well as in terms of providing farmers with adequate inputs. But on the other hand, productivity will also be affected by the sustainability and the scope of the input-credit scheme. What follows attempts to capture the overall effect of reform to get a sense of the balance of all these effects.

(c) Graphical evidence

Figures 1 to 4 show the evolution of average yields and area under cotton cultivation across different groups of countries before and after the reforms. The vertical lines indicate the reform dates. Figures 1 and 2 suggest that yields were higher after the reforms in countries where reforms were introduced. In WCA, Figure 1 shows that yields remained above 1 ton/ha post-reform in countries where regulation was adopted, that is, around their level of the 1990s, whereas they decreased to lower levels in countries where the cotton sector remained monopolistic.

[*Figure 1 about here*]

Figure 2 suggests that yields jumped post-reform in ESA countries after competition was introduced. The impact is particularly strong in countries that introduced strong competition post-reform, where pre-reform yields were lower. This is in line with what we expected, that is, a positive impact of competition on yields, greater the greatest the level of competition.

[*Figure2 about here*]

Figure 3 suggests that, after the reforms, countries where reforms were introduced in WCA had, on average, a greater area sown with cotton compared to countries where no reform was introduced. The decline in the area cultivated with cotton post-2005 followed from an increase in international input prices, which are linked to energy prices. This price rise undermined cotton production profitability until the international price for cotton also increased since 2010 (this is not captured in our dataset that stops in 2008; Delpeuch, 2011). This issue being exogenous to the reform process, it is not surprising that both control and treatment countries are affected. ESA countries have been much less affected by this phenomenon because cotton production is less intensive in inputs thanks to more favourable agro-environmental conditions.

[*Figure 3 about here*]

In ESA (Figure 4), the impact of reforms on the area cultivated is more difficult to identify graphically due to large heterogeneity among countries and important variations through time, especially in countries where strong competition was introduced.

[*Figure 4 about here*]

3. MODEL AND IDENTIFICATION STRATEGY

Nerlovian expectation models enable the estimation of acreage and yields adjustments following price changes.[4][3] The basic relation between production in period *t*, production in period *t-1* and producer prices in period *t-1* is typically expanded to include substitute products and input prices, as well as various controls for weather conditions (and water resources when crops are irrigated, but this is not the case of cotton in the countries under consideration), agricultural policies or technological change.

The particularity of our approach rests in the way we indirectly account for the inputs and output prices. Instead of estimating directly the impact of those prices, we estimate the impact of the determinants of price variation to be able to examine the link between market organization and performance, including through the impact of market organization on prices.

The central element of our strategy is the inclusion of precise market organization indicators, which describe the level of competition and involvement of the private sector, taken from Delpeuch and Leblois (2013). The additional determinants of price variation considered are the international prices of cotton and inputs and national exchange rates. The fluctuation of the dollar value of local currencies indeed plays a key role in the profitability of cotton production, as exchange rate fluctuations have been of far greater magnitude, in some countries, than the fluctuations of world cotton or inputs prices in dollars. We also include an interaction term between the exchange rate and a dummy variable denoting the CFA Franc (CFAF) zone after 1994. This controls for the lasting effect of the 1994 devaluation of the CFAF, which boosted cotton production in the region by improving producer prices, although all the price rise was not entirely passed on to farmers (Goreux and Macrae, 2003).

To account for the impact of past yields and acreage, we take advantage of the long time series dimension of our panel to exploit its dynamic dimension. Following Kanwar and Sadoulet (2008), we estimate our model in an auto-regressive framework, the difference generalized method of moments (GMM), which takes into account potential autocorrelation of the dependent variables by adding the lags of those variables in the estimation model. This allows having consistent estimators in spite of dynamic panel biases (see, among others, Nickell, 1981; Anderson and Hsiao, 1982; Arellano and Bond, 1991 and Blundell and Bond, 1998).[5] This approach is particularly justified for the cultivated area which is knowingly influenced by past decisions (Kanwar and Sadoulet, 2008).

First-differencing allows accounting for supply response determinants which vary only on a geographical basis, such as the intrinsic quality of soil for cotton cultivation or climate. Note that international prices fall in the differencing.

In addition, we also control for the effect of country-specific weather shocks using temperature and rainfall indices interacted with agro-climatic zone dummy variables to allow for a differentiated impact of these indices according to regional agro-climatic specificities. Rainfall and temperatures are indeed known to be important determinants of cotton growth (Blanc, 2008; Sultan, 2010, Luo, 2011). We also account for the effect of conflicts, which have been found to significantly disrupt production, notably by Kaminski *et al.* (2011) in the context of the recent Ivorian crisis.

The estimated equations can be written as follows:

$$dLog(Y_{i,t}) = \beta_0 + \alpha.dLog(Y_{i,t-1}) + \beta_1.dI_{i,t} + \beta_2.\mathrm{d}X_{i,t} + \beta_3.\ dWr_{i,t} + dyear_t + \varepsilon_{i,t} \qquad (1)$$

$$dLog(A_{i,t}) = \beta \quad + \alpha.dLog(A_{i,t-1}) + \beta_1.dI_{i,t} + \beta_2.dX_{i,t} + \beta_3.dWa_{i,t} + dyear_t + \varepsilon_{i,t} \tag{2}$$

where $Y_{i,t}$ denotes yields in country *i* and year *t; $A_{i,t}$* the area cultivated in country *i* and year *t*; *Ii,t* the vector of time- and country-specific institutional variables (the market organization indices); $Wr_{i,t}$ the vector of realized weather indices (i.e. weather conditions during the crop cycle); $Wa_{i,t}$ the vector of pre-sowing weather indices (i.e. weather conditions in the three months preceding sowing), which we take as a proxy for anticipated weather; and $X_{i,t}$ the vector of additional time- and country-specific controls. The βs are the parameters to be estimated, $year_t$, the year fixed effects and $\varepsilon_{i,t}$ the error term.

Alternatively, we also estimate the model with ordinary least squares (OLS) the most standard static model used for estimating parameters with multilinear regression analysis. The model includes the same variables as in the GMM estimation – except that, as the model in not differenced anymore, country- fixed effects ($country_i$) are included. This estimation strategy is comparable to a simple difference-in-difference framework as described in Bertrand *et al.* (2004), comparing the variables before and after the reforms. To ensure that our results do not suffer from a serial correlation bias in this second specification, we follow Bertrand *et al.* (2004) in "ignoring time series information" and start by regressing performance outcomes – $Log(Y_{i,t})$ or $Log(A_{i,t})$ – on fixed effects ($year_t$ and $country_i$) and on time- and country-specific controls ($X_{i,t}$). We then obtain the effects of the market organization variables from a second OLS regression on the residuals of the first regression.

The estimated equations can be written as follows:

$$Log(Y_{i,t}) = \beta_0 + \beta_2.X_{i,t} + \beta_3.\ W_{ri,t} + year_t + country_i + \varepsilon^Y \tag{3}$$

$$\varepsilon^Y_{i,t} = \beta_0 + \beta_1.I_{i,t} + {}_{i,t} \tag{4}$$

$$Log(A_{i,t}) = \beta_0 + +\beta 2.X_{i,t} + \beta_3.\ W_{ai,t} + year_t + country_i + \varepsilon^A{}_{i,t} \tag{5}$$

$$\varepsilon^Y{}_{i,t} = \beta_0 + \beta_1.I_{i,t} + {}_{i,t} \tag{6}$$

Contrarily to the GMM estimation, the second estimation procedure does not account for the impact of past decisions and therefore issues related to potential auto-correlation cannot be excluded. However, following Bond, Hoeffler and Temple (2001) we believe it is an interesting robustness check to compare the results of the OLS and the GMM estimation procedures. This is all the more the case for the yield estimation, for which we find the unit root to be low making dynamical estimations less necessary.

4. VARIABLE DESCRIPTION AND DATA SOURCES

(a) Dependant variables

We explore the link between market organization and performance both in terms of productivity, the typical indicator of performance, and in terms of cultivated area (and therefore production). The size of the sector is indeed politically of interest given the strong dependence of a number of SSA economies on cotton production both in term of export revenues and households' incomes.

We exploit a panel dataset of 16 SSA countries between 1961 and 2008. The countries included are Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Kenya, Malawi, Mali, Mozambique, Nigeria, Senegal, Tanzania, Togo, Uganda, Zambia and Zimbabwe. Together they accounted for 82% of SSA cotton production in 2008. The panel is unbalanced in that the times series start at a later date for the seven countries where independence was gained after 1961 and for which we did not have reliable information to construct the market organization indices before the independences (the incomplete series start in 1962 for Malawi and Uganda; 1963 for Kenya and Zambia; 1964 for Tanzania; 1975 for Mozambique and 1980 for Zimbabwe). There are however no gaps within each country-specific times series. The panel therefore counts 766 observations.

Data for acreage (Ha) and yields (Kg/Ha) of seed cotton, that is, the raw product, is available from the Food and Agriculture Organization of the United Nations (FAO).[6] Following Schlenker and Lobell (2010), yields and acreages are log-transformed.

(b) Institutional variables

We characterize cotton markets, on a country and year basis, building on four types of market organization rather than simply differentiating between pre- and post-reform periods. *Monopoly* describes a situation where a parastatal or a marketing board (at least partly public) has a monopsony on the purchases of raw cotton from farmers at a fixed price and a monopoly on selling cotton on the international market. Cameroon, Chad, Mali and Senegal, which retained monopolistic cotton markets until the end of the panel, constitute the control group in the most recent years when all other countries introduced reforms.

Regulation implies that a small number of firms operate as regional monopsonies or that supply is administratively allocated among firms. *Low Competition* involves that a small number of firms with large market shares exert price leadership. *Strong Competition* indicates that many firms compete on prices. These variables are exclusive: at one point in time, only one of these four variables is equal to one in a given country. *Post Reform*, which is used alternatively to the above variables as a first test, indicates that *Monopoly* is abandoned for one of the three other market organization types we have identified.

In addition, we differentiate between former French colonies and other countries to control both for the nature of pre-reform policies (and for the nature of post- reform regulation). The control variable takes the acronym of *Compagnie française pour le développement des fibres textiles* (CFDT), the French parastatal which operated the cotton sector during the colonial period, and even for some time after in all these countries ($CFDT = 1$ for former French colonies). While an imperfect policy measure, this controls for the fact that, pre-reform, cotton was given a special role in former French colonies where governments invested more in research and extension than their counterparts; investments which are believed to have enduring effects even in more recent periods when the difference in terms of investment is less clear (Tschirley *et al.*, 2009). Post-reform, this controls for the fact that all the former French colonies retained price fixation and very large-scale input credit schemes.

(c) Control variables

We control for the impact of realized weather on yields with four indices: the length of the cotton growing season, that is, the number of months between sowing and harvesting (*Season_length*); a measure of cumulative rainfall (*Rainfall*) and average and maximum monthly temperatures (*Av_temp* and *Max_temp*) during this growing season. The length of the growing season is of interest because the cotton tree development depends on the timing of precipitation in addition to the quantity of precipitations and temperatures (WMO, 2011; Sultan et al., 2010). To control for the impact of weather anticipation on decisions to plant cotton, we control for cumulative rainfall in the three months preceding sowing (*Pre-sowing Rainfall)*. The construction of these indices uses data at the cultivation zone level produced by the Climatic Research Unit of the University of East Anglia (2011) and land use data from Monfreda et al. (2008). Greater details about the construction of the weather indices such as the definition of the sowing and harvesting windows and the definition of the climatic zones are given in Appendix A.

The exchange rate data is taken from the Penn World Tables (Heston et al., 2011). It is expressed as national currency units per one thousand US dollars, averaged annually.

Dummy variables denoting different types of conflicts are taken from the UCDP/PRIO Armed Conflict Dataset (2009); they are described in Appendix B.

5. ENDOGENEITY

It could be argued that selection into reform (and thus market organization) was not random and that poorly performing countries were compelled to introduce reforms when performance deteriorated. This raises concerns over the existence of potential endogeneity issues.

A number of prima facie evidence elements however suggest that reform implementation has not been directly linked to market performance. Indeed, reforms took place in very different performance contexts while countries with relatively similar performance in terms of both yields and area have and have not adopted reforms. It is to be expected that reforms have rather been influenced by the way in which international financial institutions (IFIs) promoted structural adjustment plans. The fact that reforms happened almost at the same time (between 1993 and 1995 except for Mozambique and Nigeria where it occurred in 1986) in most countries of ESA provides additional evidence that reforms were largely driven by IFI-specific determinants rather than country and cotton sector-specific determinants. Conversely, in WCA, competition has been seldom introduced, partly because the French co-operation agency (*Agence Française de Développement*) played an important role in opposing the introduction of competition pushed forward by IFIs (Bourdet, 2004).

The fact that reforms were part of a wider reform agenda however suggests another potential endogeneity problem: what we capture as being the effect of cotton market reforms could reflect the impact of structural adjustment more generally. To formally address potential mean reversion processes, one would ideally like to instrument the reforms. To our knowledge, there is, yet, no suitable instrument to do so. Instead, we include structural adjustment as an additional explanatory variable to make sure that we are not attributing to cotton sector reforms the effects of structural adjustment (the inclusion of the exchange rate also contributes to controlling for the more general influence of macro-economic reforms).

Post-SA is a dummy variable that takes on the value one after a structural adjustment plan has been adopted. The variable is based alternatively on two different datasets displayed in Swinnen *et al.* (2010) and starts either with the year the country received its first structural adjustment loan from the World Bank or with the year preceding continuous and uninterrupted openness of a country. Using one or the other definition did not make a difference to the results. The results presented use the first definition.

Additionally, we test whether mean reversion processes could explain some of our results. Following Chai et al. (2005), we estimate the impact of false pre-treatments (reforms leads by 5, 10, 15, and 20 years) and test for the *endogeneity* of the timing of the reform process by including the date of the reform. None of these variables is found to have a significant impact on yields or area. This suggests that the effects of later reforms are not determined by pre-reform performance.

6. RESULTS

(a) Core results

Tables 1 to 3, in the Appendix, display the results of the GMM estimation of the yield, area and production regressions. Tables 4 to 6, also in the Appendix, display those of the OLS estimation. Table 7 summarizes the elasticities of interest derived from the estimated coefficients.

[Table 7 about here]

As can be seen from Table 7, one key finding seems to be confirmed by both estimation techniques: as suggested by graphical evidence, yields were positively impacted by reforms. The impact is meaningful: on average, production per hectare seems to have been 8 and 30% higher in countries where reforms were introduced compared to countries where the sector remained monopolistic, all other things equal.

The magnitude of the effect however varies with the region and the type of reform introduced. As expected, impacts are greater in ESA, where reforms where further reaching. Yields also increased more in strongly competitive markets than in moderately competitive markets. According to OLS results, the impact on yields is not even significant in the latter.

These gains in land productivity however do not seem to have materialized into total production increases in ESA countries. OLS results indicate that production would even have been lower in strongly competitive markets by about 24% due to a significant decrease in area cultivated.

A decrease in area cultivated post reform could be the result of the exit of farmers who faced more difficult difficulties in accessing inputs in a liberalized sector. Delpeuch and Vandeplas (2012) indeed show

how maintaining input-credit schemes is indeed more challenging the greater the level of competition as the scope for "side-selling" increases with competition: farmers have more opportunities to sell their cotton to other higher-bidding buyers at harvest instead of to the company that has pre-financed the inputs. In the case when such side-selling leads to the collapse of input-credit schemes, the least efficient farmers, who face the greatest difficulties in accessing inputs directly, are likely to exit the production process. Such a selection effect could, in turn, partly explain the larger yield improvement in strongly competitive markets.

While the selection effect is not confirmed by the GMM results, it is in line with previous case-country studies. Brambilla and Porto (2011) for example observed this phenomenon when they examined the Zambian cotton reform experience: the input-credit system was challenged by liberalization, leading to market exit. However, both the input system and production recovered when a number of processing firms exited the sector and cooperation between the small numbers of remaining firms led to an only moderately competitive sector.

Results on productivity and in terms of area under cultivation and production are very different in WCA.[7] On the one hand, the productivity response is more modest in these countries, with yields between 2 and 4% higher in regulated sectors than in sectors that remained monopolistic. And on the other hand, OLS results suggest a large increase in area cultivated in the regulated sectors of WCA as was suggested by Figure 1; with an equally large positive net effect on production. This would suggest significant entry of new cotton farmers in region, or expansion of cultivation on new land. Again, while the increase in cultivated land in the regulated sectors of WCA is not confirmed by GMM results, it is in line with previous case studies. In WCA, reforms did not challenge the input-credit schemes, as no competition was introduced. On the contrary, the idea was to improve the functioning of the sector and thus production incentives, notably by improving the producer price determination procedure. Looking at the Burkinabe reform experience, for example, Kaminski *et al.* (2011) find that the reform participated in boosting production, through cultivated land expansion, albeit at the cost of state transfers needed to maintain high producer prices.

Our results suggest another hidden cost of this type of reform: an only timid improvement of productivity, partly due the absence of increased selection into cotton cultivation. Entry of less productive farmers or land into cotton production post-reform may indeed hide stronger productivity impact of reforms at farm level in the most productive farms.

In addition to these cotton-specific findings, our results also confirm the intuition that the nature of pre-reform policies and post-reform market organization has to be considered to find significant results and illustrate the interest of looking at the impact of structural adjustment in African agriculture in a difference-in-difference framework using precise institutional variables. The apparent contradiction between the finding by Brambilla and Porto (2011) and those by Kaminski *et al.* (2011) is explained by the different nature of post-reform market organization in the countries considered. A general indicator of reform would not have given any insights into the effects of reforms on performance as can be seen looking at the coefficients of the *Post Reform* indicator in tables 1 to 6.

(b) Additional results

A number of additional points are worth noting to validate our estimation strategy. First, we do not find evidence of reverse causality, which suggests that endogeneity is not biasing our estimates. Table 8 and 9 display the results of the GMM estimation of our model, respectively for yield and area cultivated, with the additional variables controlling for potential reverse causality: the date of reform, the reform leads and the structural adjustment dummy variable. Table 10 gives the results of OLS estimation. None of these variables is found to have a significant impact on yield or area in any specification.

Second, the coefficients on the weather indices are in line with the agronomic literature and confirm the significance of the length of the rainfall season and the timing of rainfall, a result previously identified in Blanc et al. (2008). It is interesting to note that the size of the effects of some of the weather indices is not negligible, even when compared to the size of the effects of reforms. The impact of the length of the cotton growing season on yields in the Sudano-Sahelian climatic zone, for example, is associated with significant yield growth. This suggests that there are potential tools for stimulating cotton productivity through agronomic research on climate change adaptation, water management for instance through irrigation or yield and weather risk using index-based insurances.

7. CONCLUDING REMARKS

This paper estimates the impact of market organization on the performance of cotton markets, both in terms of area cultivated and productivity. We find that market organization is a meaningful and significant determinant of market performance and that the impact of changes in market organization has been very different in Francophone WCA and in the rest of SSA. In ESA, reforms seem to have improved yields significantly. The effect on production, however, seems to have been much more limited, if not negative in the case of highly competitive markets. Conversely, in WCA, regulatory reforms have not had a strong impact on yields, but there are indications that they have increased the size of the sector in terms of cultivated land and production.

These findings bear important implications for policy-making. Declining or stagnating production is not a problem if it results from a reallocation of resources according to comparative advantage, especially if it is accompanied by rising productivity, and if there are alternative sources of revenue both at farm and national level. However, it is more problematic in the case of a strong dependence on one sector as is the case in several countries of WCA both at household and national levels. On the other hand, stagnating yields is not satisfactory in a situation of strong dependence on a particular sector, especially if that sector is growing in size. The perspective of liberalization in WCA should therefore not be abandoned in the face of the significant impact it has had on yields in ESA. But it should probably be considered with caution given the impact of reforms in ESA on land under cultivation and total production, all the more that a collapse of the input credit schemes in WCA could have a larger impact on production in this region because production is more intensive in inputs due to environmental conditions.

The key conclusion of this paper might thus be that market organization of the sector cannot alone promote productivity and output growth at the same time in the short run. Ironically enough, it suggests that attention may therefore have to be shifted away from cotton-only reforms towards re-invigorating agricultural productivity and production as a whole. The creation of innovative input access mechanisms and efficient (and targeted) social safety-nets which would not be tied to the production of one particular crop appears as the key priority. In the long term, institutional reforms that would lead to better contract enforcement mechanisms and the development of rural credit markets remain the first-best option. Introducing competition in the cotton sector to the benefit of both yields and producer prices (Delpeuch and Vandeplas, 2012; Basset, 2014) would then pose much less collateral problems.

Additional work on the effects of reforms in particular countries, building on household level data (for example along the lines of the study by Brambilla and Porto, 2011), or on in-depth evaluations of national reform processes and market structure dynamics (Basset, 2014) would contribute to a better understanding of the national dynamics underlying the trends identified in this paper, which reflect average effects. Such studies could also shed light on the different sources of productivity and production improvements identified post-reform, notably differentiating between the impact of entry in cotton production or selection out of cotton on the one hand and that of technological and/or institutional advances that directly increased productivity or production on the other hand. Finally, political economy analysis of reform processes (along the lines of, for example, Serra, 2014), will enable understanding how ambitious reforms can be envisioned to realistically accommodate political and social objectives while improving the economic performance of the sector.

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9. ENDONOTES

[1] Differences in the legal and economic environment and enabling institutions have also been identified as a determinant of supply response (Jayne et al., 1997; Kherallah et al., 2002). However, this factor is more likely to explain broad differences in outcome between developing regions than within SSA, where the legal and economic environment and enabling institutions are relatively homogeneously low.

[2] Among the main producing countries in SSA, Tanzania is the only where this is not the case.

[3] The large scale on which input credit schemes are distributed in WCA was made possible by the monopolistic nature of the market. Since these inputs were partially used for other crops, including food crops for which it is very difficult to obtain input credits, the cotton policy has almost become a social or rural development policy. Whether the money invested in the cotton input credit scheme could have been better invested, in terms of poverty reduction, through more direct social policies with an alternative targeting system lies beyond the scope of this paper.

[4] See Sadoulet and de Janvry (1995) for a thorough review of supply response analysis models.

[5] The Hansen J test proposed by Arellano and Bond (1991) recommends the use of an AR(2) specification in the case of yields and an AR(1) in the case of area under cultivation. The presence of heteroskedasticity is tested using the panel heteroskedasticity test described by Greene (2000), which produces a modified Wald statistic testing the null hypothesis of group wise homoskedasticity. It shows that heteroskedasticity is not an issue. Based on the Westerlund ECM panel cointegration test, we also rule out cointegration

[6] The quality of data reporting for Sub-saharan African agriculture, notably the inter-annual variation of FAO data, has often been questioned. We however believe that this is true to a much lesser extent for cotton because the sector has historically been closely monitored by large (often public) firms who had an interest in recording information because input credit repayment is dependent on such data. In addition, our identification strategy does not rely on the inter-annual variation of production or yields data. Finally, as a robustness check, we also run our regressions on alternative data from the International Cotton Advisory Committee (ICAC), validating the results. The results of these additional regressions are available from the authors upon request.

[7] Looking at these results, a note should be made to recall the distinction we make between countries that introduced a regulatory system in countries that were previously managed by the CFDT and those that did so in other contexts (referred to as non CFDT). In countries where the cotton sector was developed under the auspices of the CFDT and continued to be regulated with similar policies and objectives after the Independences, price fixation and very large-scale input credit schemes have been preserved post reform. The introduction of regulation is therefore expected to have a different impact in countries that introduced regulation in a CFDT context. Mozambique being the only country to fall in the category Regulation (non CFDT), we refrain from drawing any conclusions from this specific finding.

10. APPENDIX

(a) Weather indices and climatic zones

Following Schlenker and Lobell (2010), the weather indices are computed over all .5 by .5 degree grid cells falling in a country's boundaries, weighted by the share of crop land dedicated to cotton cultivation in each grid cell. These shares are taken from Monfreda et al. (2008). They are based on national and subnational statistics matched with estimated agronomic potential for cotton cultivation for the year 2000 at the 5 arc-minute level. The major limitation associated with the use of the Monfreda et al. (2008) dataset is the fact that it rests on a static estimation of land use as it is only available for 2000. However the potential for cultivating cotton (estimated with satellite data and agricultural inventories) is little submitted to time variations. This should therefore affect our estimation only marginally. The onset and offset of the growing season are defined, as in Blanc et al. (2008), by fixed percentages of annual rainfall: the onset of the rainfall season corresponds to the month, after the first rainfall, when 5% of annual cumulative rainfall has fallen. The offset corresponds to the month when 90% of the annual cumulative rainfall has fallen.

We specify a quadratic impact of all the weather indices when it is found to be significant, in order to control for a non-linear relationship between cotton yield and weather as in Blanc et al. (2008). Contrary to the dependent variables, weather indices are not log-transformed, following Schlenker and Lobell (2010) and Blanc (2012). While cotton is mostly grown under (relatively dry) sub-humid tropical savanna, rainfall patterns vary within this climatic region. To allow for the impact of weather indices to vary between sub-regions, we distinguish, between four climatic zones (when they were found to be significant):

- The Sudano-Sahelian (semi-arid) climate zone includes Burkina-Faso, Chad, Mali, Nigeria and Senegal. It is characterized by an estimated average of 990 mm annual cumulative rainfall over the period considered.
- The Guinean (sub-humid) climate zone includes Benin, Cameroon, the Ivory Coast and Togo. It is more humid, with 1250 mm of annual cumulative rainfall on average.
- The semi-arid Eastern zone includes Kenya, Zimbabwe and Zambia. It is the driest area of Eastern Africa, with annual cumulative rainfall of 810 mm on average.
- The sub-humid Eastern zone includes Mozambique, Tanzania, Uganda and Malawi. It is characterized

by 1100 mm of annual cumulative rainfall.

(b) Conflicts

Three binary dummy variables are considered, each indicating whether at least one conflict of three types occurred during year *t* in country *i*. ’Conflict Type 2’ indicates an interstate armed conflict, ’Conflict Type 3’ an internal armed conflict opposing the government to one or more internal opposition group(s) and ’Conflict Type 4’ an internationalized internal armed conflict occurring between a government and one or more internal opposition group(s) with intervention from other states (UCDP/PRIO, 2009: codebook). The first type reported in the database, Conflict Type 1, is excluded as it refers to conflicts occurring between a state and a non-state group outside its own territory.

11. FIGURES

Figure 1: Average cotton yield in WCA: countries where reform led to a regulated sector vs. countries where no reform was adopted.

Note : The vertical lines indicate the dates when reform was introduced: Benin (1995), Burkina Faso (2004), Ivory Coast (1994) and Togo (2000).

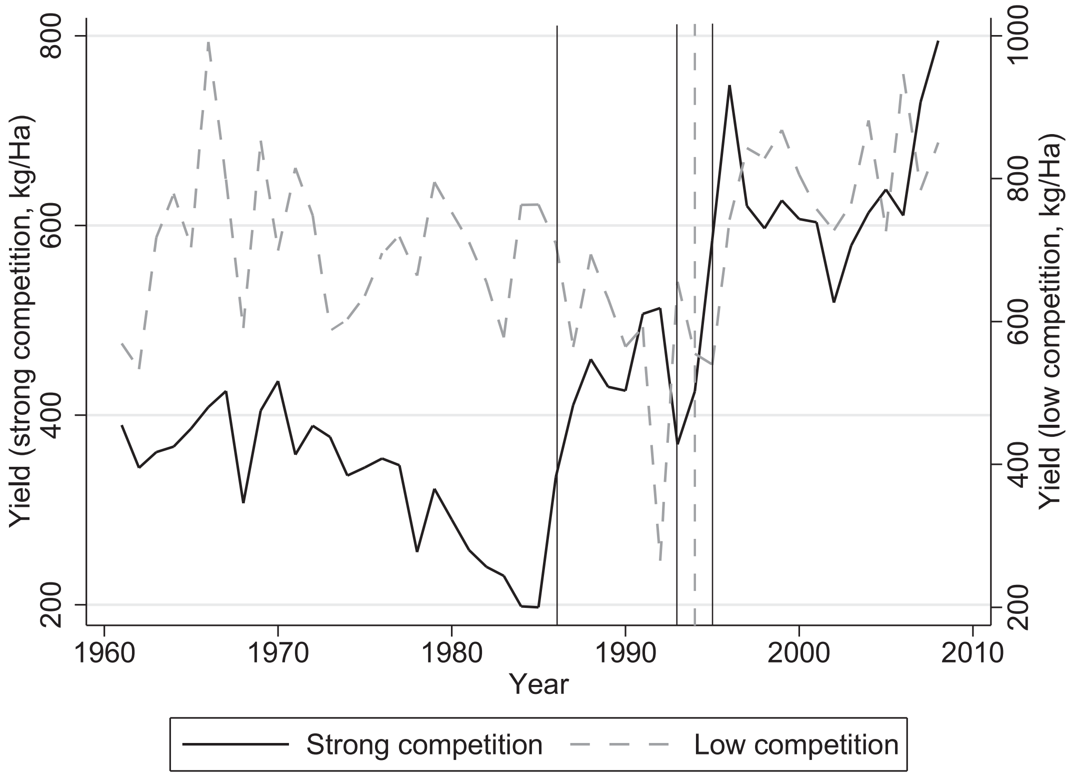

Figure 2: Average cotton yield (kg per Ha) in countries where low competition dominated post reform vs. in those where strong competition dominated.

Note: The vertical lines indicate the dates when reforms were introduced. Low competition includes Malawi Uganda, Zimbabwe and Zambia where reforms were introduced in 1995. Strong competition includes Kenya, Nigeria and

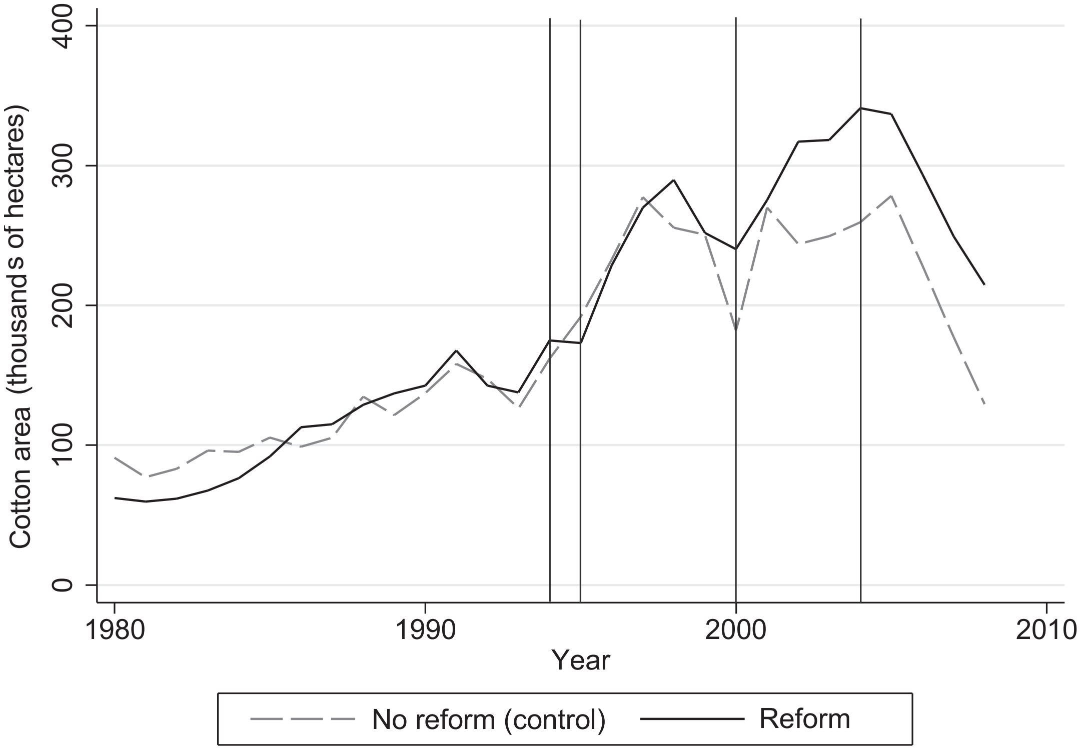

Figure 3: Average cotton area in WCA: countries where reforms led to a regulated sector vs. countries where no reform was adopted.

Note : The vertical lines indicate the dates when reform was introduced: Benin (1995), Burkina Faso (2004), Ivory Coast (1994) and Togo (2000).

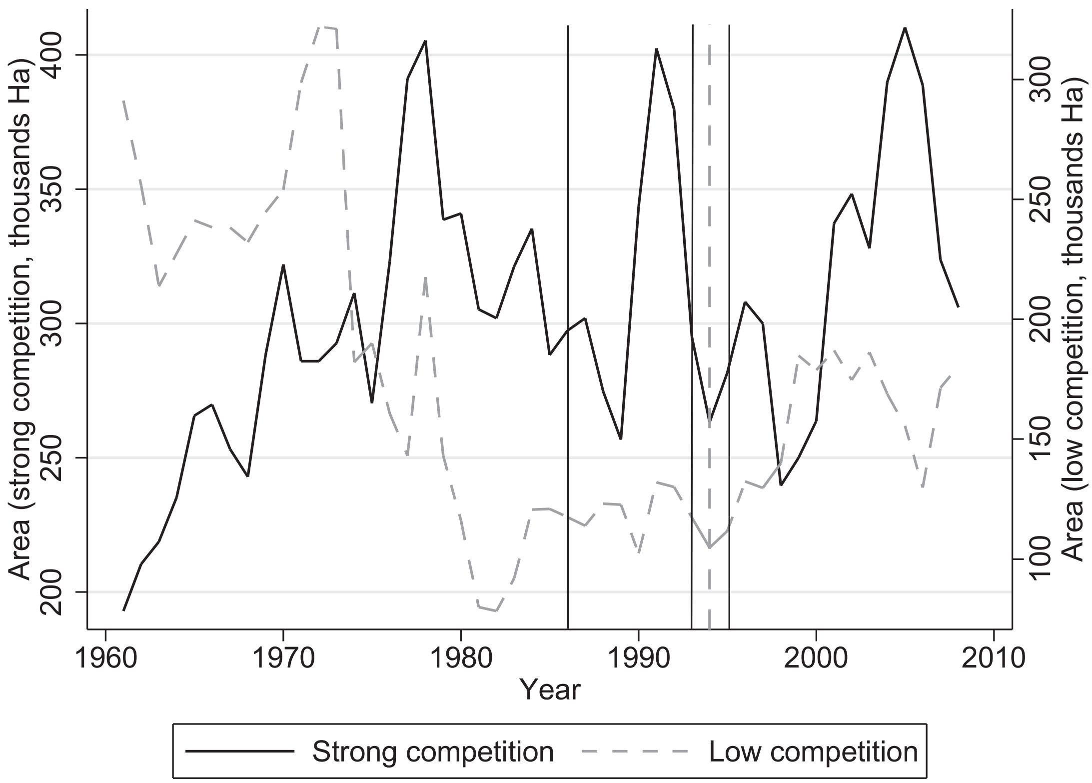

Figure 4: Average cotton area (thousand Ha) in countries where low competition dominated post reform vs. in those where strong competition dominated. The vertical lines indicate the dates when regulation was introduced.

Note: The vertical lines indicate the dates when reform was introduced. Low competition includes Malawi Uganda, Zimbabwe and Zambia where reforms were introduced in 1995. Strong competition includes Kenya, Nigeria and Tanzania where reforms were introduced, respectively, in 1986, 1994 and 1996.

12. TABLES

Table(s)

Table 1: Cotton Market Structure and Yield (GMM)

	(1) log_y	(2) log_y	(3) log_y
L.log_y	0.546***	0.544***	0.533***
	(0.0330)	(0.0316)	(0.0330)
L2.log_y	0.189***	0.187***	0.191***
	(0.0349)	(0.0351)	(0.0353)
Post_reform	0.115***		
	(0.0332)		
Regulation		0.0987**	0.270***
		(0.0496)	(0.0744)
Regulation_CFDT			−0.251***
			(0.0784)
Low Competition		0.0886***	0.150***
		(0.0305)	(0.0461)
Strong Competition		0.142**	0.176***
		(0.0597)	(0.0670)
Post_SA	−0.0400	−0.0396	−0.0456
	(0.0452)	(0.0447)	(0.0441)
Max_tmp	−0.0158*	−0.0159*	−0.0190**
	(0.00887)	(0.00917)	(0.00826)
sq_max_tmp	0.0000368*	0.0000377*	0.0000436**
	(0.0000218)	(0.0000227)	(0.0000209)
Av._tmp	0.00317	0.00290	0.00258
	(0.00287)	(0.00271)	(0.00261)
Cum._Rainfall	0.00872	0.00880	0.00832
	(0.0213)	(0.0214)	(0.0214)
Cum._Rainfall_Zone2	−0.0291	−0.0283	−0.0232
	(0.0219)	(0.0224)	(0.0228)
Cum._Rainfall_Zone3	0.00716	0.00592	0.00467
	(0.0171)	(0.0169)	(0.0165)
Cum._Rainfall_Zone4	−0.0166	−0.0165	−0.0165
	(0.0287)	(0.0288)	(0.0277)
Length	0.449***	0.443***	0.454***
	(0.0551)	(0.0526)	(0.0470)
Length_Zone2	0.482	0.473	0.444
	(0.371)	(0.370)	(0.352)
Length_Zone3	−0.929***	−0.906***	−0.901***
	(0.246)	(0.246)	(0.244)
Length_Zone4	−0.421***	−0.423***	−0.404***
	(0.118)	(0.116)	(0.120)
sq_length	−0.0466***	−0.0459***	−0.0464***
	(0.00849)	(0.00843)	(0.00816)
sq_length_Zone2	−0.0371	−0.0366	−0.0350
	(0.0309)	(0.0309)	(0.0294)
sq_length_Zone3	0.0752***	0.0735***	0.0730***
	(0.0161)	(0.0163)	(0.0162)
sq_length_Zone4	0.0411***	0.0410***	0.0395***
	(0.0117)	(0.0115)	(0.0116)
Log Xrate	0.00371	0.00381	0.000978
	(0.00955)	(0.0108)	(0.00961)
ZF_ExR	−0.142	−0.141	0.0152
	(0.150)	(0.189)	(0.205)
Conflict Type2	0.0919	0.0925	0.0945
	(0.107)	(0.108)	(0.110)
Conflict Type3	−0.0189	−0.0193	−0.00936
	(0.0387)	(0.0383)	(0.0406)
Conflict Type4	−0.115***	−0.116***	−0.137***
	(0.0414)	(0.0406)	(0.0526)
Constant	2.604**	2.700**	3.131***
	(1.232)	(1.268)	(1.133)
Observations	691	691	691
AB p-value of AR(3)	0.1274	0.1312	0.1364
P-value of Sargan test 0.3005	0.2904	0.3101	
P-value of Wald test	0.0000	0.0000	0.0000

Robusts standard errors in parentheses
AB p-value refers to the Arellano-Bond test for no autocorrelation.
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 2: Cotton Market Structure and Area (GMM)

	(1) log_area	(2) log_area	(3) log_area
L.log_area	0.850***	0.839***	0.841***
	(0.0211)	(0.0254)	(0.0242)
Post_reform	0.0379		
	(0.0710)		
Regulation		0.113*	0.136
		(0.0617)	(0.164)
Regulation_CFDT			−0.0336
			(0.172)
Low Competition		−0.0205	−0.0121
		(0.106)	(0.127)
Strong Competition		−0.0578	−0.0516
		(0.0813)	(0.0967)
Post_SA	0.0929**	0.0897**	0.0887**
	(0.0380)	(0.0379)	(0.0354)
Pre_Sowing_Rainfall	−0.233	−0.233	−0.234
	(0.171)	(0.172)	(0.171)
Pre_Sowing_Rainfall_Zone2	0.349**	0.338**	0.340**
	(0.166)	(0.164)	(0.165)
Pre_Sowing_Rainfall_Zone3	−0.112	−0.0839	−0.0819
	(0.289)	(0.299)	(0.299)
Pre_Sowing_Rainfall_Zone4	0.256	0.239	0.239
	(0.208)	(0.201)	(0.201)
Log Xrate	0.00367	0.00326	0.00288
	(0.00690)	(0.00853)	(0.00902)
ZF_ExR	0.489***	0.309*	0.329
	(0.166)	(0.187)	(0.254)
Conflict Type2	0.0917	0.0931	0.0935
	(0.0872)	(0.0893)	(0.0901)
Conflict Type3	−0.102***	−0.0969***	−0.0953***
	(0.0266)	(0.0226)	(0.0217)
Conflict Type4	−0.281***	−0.287***	−0.289***
	(0.0885)	(0.0896)	(0.0954)
Constant	1.755***	1.967***	1.938***
	(0.267)	(0.351)	(0.370)
Observations	704	704	704
AB p-value of AR(2)	0.9689	0.9668	0.9589
P-value of Sargan test	0.8479	0.8207	0.8205
P-value of Wald test	0.0000	0.0000	0.0000

Robusts standard errors in parentheses
AB p-value refers to the Arellano-Bond test for no autocorrelation.
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 3: Cotton Market Structure and Production (GMM)

	(1) log_prod	(2) log_prod	(3) log_prod
L.log_prod	0.814***	0.806***	0.811***
	(0.0236)	(0.0247)	(0.0230)
Post_reform	0.0471		
	(0.101)		
Regulation		0.154*	0.250
		(0.0823)	(0.192)
Regulation_CFDT			−0.141
			(0.203)
Low Competition		−0.0486	−0.0143
		(0.130)	(0.162)
Strong Competition		−0.0693	−0.0478
		(0.130)	(0.154)
Post_SA	0.0669	0.0587	0.0550
	(0.0617)	(0.0638)	(0.0593)
ZF_ExR	0.000382	0.000119	0.000198
	(0.000278)	(0.000304)	(0.000394)
Pre_Sowing_Rainfall	0.0320	0.0379	0.0364
	(0.148)	(0.147)	(0.147)
Pre_Sowing_Rainfall_2	−0.0290	−0.0578	−0.0561
	(0.160)	(0.160)	(0.162)
Pre_Sowing_Rainfall_3	−0.238	−0.227	−0.228
	(0.368)	(0.372)	(0.376)
Pre_Sowing_Rainfall_4	−0.0140	−0.00650	−0.00792
	(0.238)	(0.235)	(0.238)
Max_tmp	−0.0227*	−0.0228**	−0.0242**
	(0.0123)	(0.0110)	(0.0116)
sq_max_tmp	0.0000732**	0.0000744**	0.0000766**
	(0.0000333)	(0.0000302)	(0.0000313)
Av._tmp	−0.0102**	−0.0105**	−0.0104**
	(0.00506)	(0.00494)	(0.00499)
Cum._Rainfall	−0.0203	−0.0248	−0.0238
	(0.0340)	(0.0326)	(0.0325)
Cum._Rainfall_Zone2	−0.00161	−0.00279	−0.000855
	(0.0338)	(0.0326)	(0.0333)
Cum._Rainfall_Zone3	0.0344	0.0425	0.0409
	(0.0410)	(0.0420)	(0.0425)
Cum._Rainfall_Zone4	0.00698	0.00986	0.00861
	(0.0486)	(0.0475)	(0.0477)
Lenght	0.654***	0.682***	0.694***
	(0.116)	(0.119)	(0.119)
Lenght_Zone2	0.251	0.290	0.269
	(0.264)	(0.281)	(0.273)
Lenght_Zone3	−1.350***	−1.402***	−1.419***
	(0.193)	(0.204)	(0.203)
Lenght_Zone4	−0.633***	−0.637***	−0.635***
	(0.150)	(0.147)	(0.145)
sq_Lenght	−0.0622***	−0.0653***	−0.0665***
	(0.0137)	(0.0138)	(0.0141)
sq_Lenght_Zone2	−0.0243	−0.0269	−0.0251
	(0.0218)	(0.0233)	(0.0227)
sq_Lenght_Zone3	0.104***	0.109***	0.110***
	(0.0165)	(0.0169)	(0.0173)
sq_Lenght_Zone4	0.0635***	0.0659***	0.0662***
	(0.0143)	(0.0138)	(0.0140)
Log Xrate	0.0110	0.0109	0.00942
	(0.00847)	(0.00777)	(0.00851)
Conflict Type2	0.202	0.205	0.205
	(0.170)	(0.176)	(0.176)
Conflict Type3	−0.0993*	−0.0896*	−0.0828
	(0.0522)	(0.0532)	(0.0568)
Conflict Type4	−0.314***	−0.323***	−0.329***
	(0.117)	(0.117)	(0.124)
Constant	4.030**	4.179***	4.289***
	(1.705)	(1.607)	(1.584)
Observations	704	704	704
AB p-value of AR(2)	0.2136	0.1939	0.1764
P-value of Sargan test 0.9475	0.9405	0.9452	
P-value of Wald test	0.0000	0.0000	0.0000

Robusts standard errors in parentheses
AB p-value refers to the Arellano-Bond test for no autocorrelation.
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 4: Cotton Market Structure and Yield (OLS, fixed effects)

	(1) Residuals yield	(2) Residuals yield	(3) Residuals yield
Post_reform	0.110***		
	(0.0341)		
Regulation		0.117**	0.181**
		(0.0519)	(0.0736)
Regulation_CFDT			−0.115
			(0.0935)
Low Competition		0.0231	0.0228
		(0.0577)	(0.0577)
Strong Competition		0.151***	0.151***
		(0.0447)	(0.0447)
Post_SA	−0.0711**	−0.0666**	−0.0662**
	(0.0297)	(0.0299)	(0.0298)
Constant	0.00957	0.00778	0.00760
	(0.0194)	(0.0194)	(0.0194)
Observations	726	726	726
R^2	0.016	0.021	0.023
Adjusted R^2	0.013	0.015	0.016

Standard errors in parentheses, robust to clustering

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 5: Cotton Market Structure and Area (OLS, fixed effects)

	(1) Residuals area	(2) Residuals area	(3) Residuals area
Post_reform	-0.199^{***}		
	(0.0586)		
Regulation		-0.00351	-0.348^{***}
		(0.0880)	(0.123)
Regulation_CFDT			0.618^{***}
			(0.157)
Low Competition		0.0159	0.0173
		(0.0977)	(0.0967)
Strong Competition		-0.440^{***}	-0.439^{***}
		(0.0757)	(0.0750)
Post_SA	0.149^{***}	0.124^{**}	0.122^{**}
	(0.0511)	(0.0505)	(0.0501)
Constant	-0.0283	-0.0183	-0.0173
	(0.0332)	(0.0328)	(0.0325)
Observations	726	726	726
R^2	0.019	0.051	0.071
Adjusted R^2	0.016	0.046	0.064

Standard errors in parentheses, robust to clustering

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 6: Cotton Market Structure and Production (OLS, fixed effects)

	(1) Residuals production	(2) Residuals production	(3) Residuals production
Post_reform	−0.0798		
	(0.0627)		
Regulation		0.121	−0.138
		(0.0948)	(0.134)
Regulation_CFDT			0.465***
			(0.170)
Low Competition		0.0350	0.0361
		(0.105)	(0.105)
Strong Competition		−0.273***	−0.272***
		(0.0815)	(0.0812)
Post_SA	0.0676	0.0478	0.0460
	(0.0546)	(0.0545)	(0.0542)
Constant	−0.0154	−0.00758	−0.00685
	(0.0355)	(0.0353)	(0.0352)
Observations	726	726	726
R^2	0.003	0.022	0.032
Adjusted R^2	0.000	0.016	0.025

Standard errors in parentheses, robust to clustering

* $p < .1$, ** $p < .05$, *** $p < .01$

7: Core Results: cotton area, productivity and production responses to reforms.

		GMM		OLS, FE	
	Regulation	**10.24**%**		**12.2**%**	
	Regulation (non CFDT)		**30.67**%**		**19.5**%**
	Regulation (CFDT)		**8.3**%***		8.2%
	Low competition	**9.2**%***	**16**%***	2.2%	2.1%
	Strong competition	**15**%**	**19.1**%%***	**16.2**%***	**16.1**%***
	Regulation	**11.71**%*		-.74%	
	Regulation (non CFDT)		13.1%		**-29.9**%***
	Regulation (CFDT)		8.4%		**53.4**% ***
	Low competition	-2.6%	-1.99%	1.12%	1.27%
	Strong competition	-5.9%	-5.5%	**-35.8**% ***	**-35.7**% ***
tion	Regulation	**16.3**%*		12.3%	
	Regulation (non CFDT)		26%		-13.7%
	Regulation (CFDT)		11.1		**43.2**%***
	Low competition	-5.5%	-2.71%	3%	3.11%
	Strong competition	-7.5%	-5.6%	**-24.1**%***	**-24.1**%***

ore are reported in bold, elasticities have been computed using Kennedy (1981) estimation for semi-log estimations.

Table 8: Testing endogeneity on productivity: date of reforms and false pre-treatment (GMM, one-step robust estimator)

	(1)	(2)	(3)	(4)	(5)
	log_y	log_y	log_y	log_y	log_y
L.log_y	0.480***	0.524***	0.503***	0.513***	0.507***
	(0.0593)	(0.0408)	(0.0340)	(0.0317)	(0.0275)
L2.log_y	0.307***	0.197***	0.250***	0.249***	0.246***
	(0.0594)	(0.0519)	(0.0496)	(0.0451)	(0.0477)
Date_ref	−0.00253				
	(0.00428)				
F20.post_reform		−0.0467			
		(0.0695)			
F15.post_reform			−0.00515		
			(0.0351)		
F10.post_reform				0.00513	
				(0.0358)	
F5.post_reform					−0.0442
					(0.0592)
Post_SA	−0.0214	−0.0296	−0.0401	−0.0258	−0.0431
	(0.0727)	(0.0433)	(0.0385)	(0.0373)	(0.0351)
Max_tmp	−0.0277	−0.0393	−0.0352**	−0.0345**	−0.0368**
	(0.0375)	(0.0252)	(0.0173)	(0.0152)	(0.0164)
sq_max_tmp	0.0720	0.0968	0.0834*	0.0840**	0.0896**
	(0.0867)	(0.0613)	(0.0434)	(0.0397)	(0.0430)
Av._tmp	0.0791	0.0352	0.0306	0.0152	0.0420
	(0.0854)	(0.0371)	(0.0339)	(0.0286)	(0.0263)
Cum._Rainfall	0.202	0.214	0.159	0.136	0.0685
	(0.430)	(0.132)	(0.161)	(0.0990)	(0.0789)
Cum._Rainfall_Zone2	−0.226	−0.264	−0.253	−0.227*	−0.154
	(0.447)	(0.172)	(0.180)	(0.121)	(0.107)
Cum._Rainfall_Zone3	−0.269	−0.366	−0.325	−0.311	−0.234
	(0.485)	(0.386)	(0.295)	(0.259)	(0.243)
Cum._Rainfall_Zone4	−0.734	−0.475***	−0.647***	−0.627***	−0.557***
	(0.501)	(0.182)	(0.243)	(0.196)	(0.196)
Lenght	−1.145	0.322***	0.268***	0.333***	0.398***
	(1.367)	(0.0814)	(0.0793)	(0.0737)	(0.0573)
Lenght_Zone2	2.407	0.0295	0.111	0.184	0.101
	(1.599)	(0.503)	(0.429)	(0.384)	(0.380)
Lenght_Zone3	0.635	−1.017*	−0.901***	−0.973***	−1.086***
	(1.398)	(0.608)	(0.347)	(0.332)	(0.348)
Lenght_Zone4	1.225	−0.114	−0.160	−0.225*	−0.309***
	(1.375)	(0.145)	(0.135)	(0.135)	(0.119)
sq_Lenght	0.157	−0.0240*	−0.0205	−0.0262*	−0.0362***
	(0.148)	(0.0141)	(0.0154)	(0.0149)	(0.0119)
sq_Lenght_Zone2	−0.263	−0.00543	−0.0146	−0.0215	−0.0110
	(0.163)	(0.0449)	(0.0396)	(0.0335)	(0.0327)
sq_Lenght_Zone3	−0.125	0.0662*	0.0601**	0.0665***	0.0787***
	(0.149)	(0.0396)	(0.0264)	(0.0250)	(0.0236)
sq_Lenght_Zone4	−0.170	−0.00563	0.00451	0.0102	0.0213
	(0.148)	(0.0165)	(0.0172)	(0.0168)	(0.0140)
ZF_ExR	0.370	0.237	−0.00879	−0.0673	−0.139
	(0.543)	(0.468)	(0.484)	(0.413)	(0.418)
Log Xrate	0.00953	0.0278**	0.0220**	0.0234**	0.0252**
	(0.0171)	(0.0126)	(0.00919)	(0.0104)	(0.0121)
Conflict Type2	0.0819	0.199	0.196	0.184*	0.194*
	(0.207)	(0.134)	(0.133)	(0.111)	(0.113)
Conflict Type3	0.0418	0.0160	−0.00245	−0.0283	−0.0165
	(0.0741)	(0.0928)	(0.0665)	(0.0595)	(0.0536)
Conflict Type4	−0.294*	−0.126	−0.128	−0.152**	−0.132*
	(0.164)	(0.0811)	(0.0782)	(0.0680)	(0.0720)
Observations	342	365	434	471	497
AB p-value of AR(3)	0.4055	0.5416	0.6732	0.5749	0.3814
P-value of Sargan test 0.7590		0.4742	0.4643	0.7601	
P-value of Wald test	0.0000	0.0000	0.0000	0.0000	0.0000

Robusts standard errors in parentheses
AB p-value refers to the Arellano-Bond test for no autocorrelation.
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 9: Testing endogeneity on acreage: date of reforms and false pre-treatment (GMM, one-step robust estimator)

	(1) log_area	(2) log_area	(3) log_area	(4) log_area	(5) log_area
L.log_area	0.957***	0.835***	0.854***	0.855***	0.854***
	(0.124)	(0.0245)	(0.0229)	(0.0263)	(0.0221)
Date_ref	0.422				
	(0.804)				
F20.post_reform		−0.00982			
		(0.0591)			
F15.post_reform			0.0852		
			(0.0591)		
F10.post_reform				0.0626	
				(0.0461)	
F5.post_reform					−0.00931
					(0.0522)
ZF_ExR	0.00158**	0.878	0.896*	0.00122**	0.00103**
	(0.762)	(0.616)	(0.479)	(0.531)	(0.435)
Post_SA	0.184**	0.0923	0.0433	0.0762	0.0816
	(0.0790)	(0.0711)	(0.0638)	(0.0483)	(0.0611)
Pre_Sowing_Rainfall	−0.797***	−0.269*	−0.301*	−0.210	−0.329**
	(0.100)	(0.154)	(0.170)	(0.142)	(0.143)
Pre_Sowing_Rainfall_2	0.00114***	0.385**	0.396*	0.234*	0.370*
	(0.153)	(0.152)	(0.222)	(0.135)	(0.192)
Pre_Sowing_Rainfall_3	−0.0511	−0.289	−0.318	−0.361	−0.223
	(0.561)	(0.208)	(0.359)	(0.259)	(0.342)
Pre_Sowing_Rainfall_4	0.607**	0.0623	0.0946	−0.00270	0.103
	(0.300)	(0.177)	(0.262)	(0.170)	(0.243)
Log Xrate	−0.256***	−0.0747***	−0.0384**	−0.0377**	−0.0328**
	(0.0569)	(0.0280)	(0.0168)	(0.0150)	(0.0164)
Conflict Type2	0.0535	0.183**	0.221	0.143	0.134
	(0.0744)	(0.0924)	(0.144)	(0.102)	(0.128)
Conflict Type3	−0.278	−0.0604	−0.0429	−0.0513*	−0.0563
	(0.214)	(0.0693)	(0.0653)	(0.0292)	(0.0561)
Conflict Type4	−1.674***	−0.520**	−0.459***	−0.414*	−0.395***
	(0.329)	(0.240)	(0.107)	(0.215)	(0.0999)
Observations	351	378	447	484	510
AB p-value of AR(2)	0.5450	0.5400	0.5864	0.6124	0.3983
P-value of Sargan test	0.4742	0.4643	0.7601	0.7590	0.7723
P-value of Wald test	0.0000	0.0000	0.0000	0.0000	0.0000

Robusts standard errors in parentheses
AB p-value refers to the Arellano-Bond test for no autocorrelation.
* $p < .1$, ** $p < .05$, *** $p < .01$

bias on acreage and productivity (OLS, ignoring time series): false treatment before the reforms

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Res. yield	Res. yield	Res. yield	Res. yield	Res. area	Res. area	Res. area	Res. area	Res. area
					−0.000827				
					(0.0129)				
	−0.0700					−0.0951			
	(0.119)					(0.110)			
		−0.155					−0.106		
		(0.129)					(0.120)		
			−0.149					−0.0677	
			(0.110)					(0.128)	
				−0.183					−0.157
				(0.127)					(0.138)
	−0.0297	0.0314	0.0136	−0.00667	0.227	0.232	0.168	0.126	0.0809
	(0.0947)	(0.111)	(0.106)	(0.0961)	(0.135)	(0.179)	(0.178)	(0.181)	(0.182)
	385	454	491	517	350	385	454	491	517
	0.010	0.030	0.024	0.025	0.024	0.018	0.012	0.008	0.008
	0.004	0.026	0.020	0.021	0.018	0.012	0.008	0.004	0.004