WPS5861

Policy Research Working Paper 5861

The Elusive Quest for Supply Response to Cash-crop Market Reforms in Sub-Saharan Africa

The Case of Cotton

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The World Bank
Poverty Reduction and Economic Management Network
International Trade Department
October 2011

Policy Research Working Paper 5861

Abstract

Little cross-cutting conclusions emerge from comparative studies on the impact of structural adjustment on Sub-Saharan African agricultural performance. This paper aims to illuminate this long-standing debate by adopting a novel quantitative, sectoral and long-term approach controlling for country-specific determinants. It incorporates detailed information on the pace of reforms and the nature of post-reform market structure, pre-reform policies and weather conditions at the cultivation zone level. The cotton sector is the focus of this paper because of its particularly interesting institutional history.

The authors find that the changes in market structure brought about by reforms have had very different impacts in Francophone West and Central Africa and in the rest of Sub-Saharan Africa. In the former region, production has been higher but productivity lower, on average, in regulated markets than in monopolistic markets. Conversely, in the liberalized markets of the rest of Sub-Saharan Africa, productivity has been higher in than in monopolistic markets but highly competitive markets seem to have produced less than monopolistic sectors.

This paper is a product of the International Trade Department, Poverty Reduction and Economic Management Network. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at claire.delpeuch@oecd.org.

The Elusive Quest for Supply Response to Cash-crop Market Reforms in Sub-Saharan Africa: The Case of Cotton

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

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

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[3] This paper is a contribution to the DFID–supported Global Trade and Financial Architecture project. The authors would like to thank Lisa Anoulies, Marcelo Olarreaga and Philippe Quirion for very useful comments on earlier drafts (all remaining errors are ours).

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; Poulton and Delpeuch, 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, the impact of reforms is found to have varied in direction and magnitude when any was identified. Little cross-cutting conclusions thus emerge from comparative studies in SSA, except for the timidity of impacts (e.g. Kheralla *et al.*, 2002; Akiyama *et al.*, 2003).

We identified four potential sources of supply and productivity response variation in the literature on agricultural transition in developing countries (DCs) and in the literature on agricultural productivity in Africa, which could conceal overarching trends: the depth of reforms, the nature of pre-reform intervention, the institutional requirements of production processes and external forces. First, 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 (2011) 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 structure that vary widely both across countries and over time. On the one hand, in Tanzania, for example, the liberalization of the cotton sector in 1995 has led to significant entry by the private sector and relatively strong competition. But on the other hand, in other countries of East and Southern Africa (ESA) like Zambia or Zimbabwe, the degree of competition post-reform has fluctuated. Such fluctuation resulted both from private sector market entry and exit and from the introduction of new regulations by governments. Moreover, in several countries of West and Central Africa (WCA), reforms have led to private entry but price-setting mechanisms have been maintained hence strictly constraining competition. This suggests that there is scope for variation in supply response to derive from variation in reform design and implementation. A long-term perspective and precise knowledge on the nature of post-reform market structure 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). The nature of pre-reform agricultural policies has been identified as a key determinant of supply response in Asia (Rozelle and Swinnen, 2004). [4] 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 *et al.*, 2010).

Finally, many external factors interact with the reform of specific agricultural markets, among which, variations in world market conditions, domestic macro-economic policies, conflicts and, most importantly, weather conditions (Meerman, 1997).[5] With a few exceptions (e.g. Brambilla and Porto, forthcoming and Kaminski *et al.*, 2011), these external factors are rarely formally accounted for in studies of agricultural transition in SSA. In particular, while the impact of weather on agricultural productivity is estimated in the specialised literature on the link between climate and agricultural productivity (e.g. Fontaine and Janicot, 1996 and Le Barbé *et al.*, 2002 on the inter-annual and inter-decadal variability of the West African monsoon), we have not seen it included as a control in the structural adjustment literature.

This paper aims to illuminate long-standing debates about the impact of structural adjustment in SSA agriculture by addressing all of the above-mentioned issues. We adopt a novel quantitative, sectoral and long-term approach, in which we control for country-specific determinants and incorporate detailed information on the pace of reforms, the nature of post-reform market structure, pre-reform policies and weather conditions. Such detailed information is taken from two new datasets. First, we use the market structure indices compiled in Delpeuch and Leblois (2011) to inform the

[4] Swinnen and Rozelle (2004) show how supply responses were intimately linked to the nature of agricultural policies under state control in different regions of Asia and Europe: where the state had tried to force industrialization in part by taxing agriculture, eliminating distortions resulted in output growth; where the state had tried to stimulate agricultural production by subsidizing inputs or output, market pricing resulted in output decline.

[5] 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.

timing of reforms and characterize the nature of post-reform market structure. More particularly, we differentiate between monopolies on the one hand and three types of liberalized markets on the other hand. Monopolistic markets characterized all SSA cotton markets pre-reform in the period we examine. In some countries where no reform has been adopted yet, markets remain monopolistic. In such markets, parastatals or marketing boards have a monopsony on the purchases of raw cotton from small farmers and a monopoly on selling cotton on the international market. Where reforms have been adopted, markets evolved into three broad categories: regulated sectors (with several firms active in the sector but no direct competition), moderately competitive sectors (where a small number of firms exert price leadership) and strongly competitive markets. Second, we construct precise indices of weather conditions at the level of cotton cultivation zones based on the dataset provided by the Climatic Research Unit of the University of East Anglia (2011).

The cotton sector is the focus of this paper because of its particularly interesting institutional history. A large number of countries in SSA have had very similar cotton market structures for decades (a legacy of colonial policies – see the Annex of this dissertation) but have chosen reform options that differ in several dimensions. This situation thus offers a privileged testing set-up for examining variations in post-reform performance and identifying the reasons for such divergence. Besides, the policy implications of our results should be of widespread interest in SSA: cotton remains at the core of vivid policy debates as it is the main source of cash revenue for more than two million poor rural households and a major source of foreign exchange for about fifteen countries on the continent (Tschirley *et al.*, 2009).

Our findings confirm the intuition that the relation between market structure and performance is complex but that it is meaningful and significant once a number of elements are controlled for. The impact of the changes in market structure brought about by reforms notably appears to have been very different in Francophone WCA and in the rest of SSA. *Ceteris paribus*, productivity was higher in all types of liberalized markets in ESA and non-Francophone WCA. However, highly competitive markets seem to have produced less than monopolistic sectors. We attribute these results (i) to the fact that competitive markets sectors tend to offer access to inputs more restrictively (hence causing the exit of the less experienced farmers and the less productive land) and (ii) to the fact that the positive effect of competition on producer prices has, on average, been relatively limited (in part because of subsidizing in a number of regulated and monopolistic sectors).

Conversely, countries with a regulated market structure in Francophone WCA have produced more cotton than those with a monopolistic market structure, albeit with lower yields. The entry of private capital and the involvement of producers in the management of the sector have probably contributed to reinforce the attractiveness of cotton cultivation. In addition, the possibility of accessing inputs has not been challenged, even for the least efficient farmers, as the single-channel organization of the sector was maintained. We therefore interpret the lower productivity post-reform as being partly a side-effect of increased production through the use of marginal land and cultivation by less experienced farmers.

The remaining of this paper is organized as follows. In section 2 we briefly describe the expected relation between market structure and performance based on the theoretical literature (2.1) and the reforms undertaken in SSA cotton sectors (2.2). We also provide descriptive statistics on the empirical relation between market structure and performance (2.3). In section 3 we describe our estimation strategy and in section 4 we discuss our results. Section 5 concludes.

2. Reforms and Performance

2.1 Expected Relation

Market structure and institutional arrangements are believed to influence performance positively 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.[6] 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 structure and performance, however, is likely to be affected (i) by the conjunction of three characteristics of cotton cultivation in Africa (input requirements, credit constraints and limited contract enforcement) and (ii) by the nature of pre-reform policies. Cotton cultivation requires costly inputs (fertilizers and pesticides). Farmers however face strong cash

[6] The effect of reform on pricing could be more uncertain if producer associations exerted a strong influence on the price decision-making process. However, the literature rather suggests that this is not yet the case in SSA (Roy, 2010).

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.[7] In this context, the capacity of a country to produce and export cotton is highly dependent on the capacity of farmers and ginning companies to enforce interlinking contracts (Dorward *et al.*, 2004). Delpeuch *et al.* (2010) formally show that because contract enforcement mechanisms are at best imperfect in many African countries, the sustainability of interlinking is highly influenced by market structure. 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 structure is thus to facilitate the sustainability of input provision on credit.[8] The link between the scale of input-credit availability and productivity is however ambivalent. Indeed, as noted by Brambilla and Porto (forthcoming), while inputs allow farmers to increase their efficiency; 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 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 while 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, Schiff and Valdes, 1988; Anderson and Masters, 2009; Bates and Block, 2009).[9] The magnitude and the direction of state price intervention in cotton markets, however,

[7] Among the main producing countries, Tanzania is the only where this is not the case at all.

[8] Other characteristics of state monopolies have been discussed. Their system of pan-territorial and pan-seasonal price fixation has, for example, been heralded as a risk mitigation and spatial redistribution instrument (Araujo Bonjean et al., 2003) and criticized as an ineffective tool of rural development promotion (Baghdadli et al., 2007). It is however beyond the scope of this paper to discuss such issues.

[9] Because agriculture represents a large share of national GDP in developing countries and in Africa in particular it has, on average, been largely taxed as governments have little alternative sources of income at their disposal. The large number of farmers also implies that collective action among them to oppose taxation is costly (Olson, 1985) and that support to farmers would be costly to the society (Swinnen, 2010). In addition, exported cash crops are considered to be a relatively easy target for taxation, because it is easier to control exports than

have varied according to the world price (and the objectives of governments). 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.[10] Nubupko and Keita (2005) for example find that, in Mali, the negative macroeconomic impact of a 20 percent drop in producer prices would be bigger than the positive impact of the budget saving that would allow such a reduction. Indeed, the drop in cotton prices would imply a reduction of producer revenues and consumption, with negative effects on the revenues of non-producers, lower revenues for cotton transformation firms as well as lower imports of inputs (and hence reduced government taxes). These effects are bigger the more elastic production is to prices. In line with such predictions, Baffes (2007) reports that cotton companies in WCA have received budget support between 1985 and 1993 and again since 1998, at times when they faced financial difficulties.

In summary, competition is expected to influence production incentives positively unless input-credit schemes collapse and/or the effect of competition is offset by the elimination of state support. The expected relation between market structure and yields is even more ambivalent as, if research and extension services are not scaled up, increasing production is ultimately likely to result in declining average yields.

2.2 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.[11] In addition, prices were fixed by governments or administrative bodies, and sales were guaranteed for producers. Following recommendations by the World Bank and the International Monetary Fund, SSA cotton sectors have however seen their share of reforms starting in the late 1980s and increasingly

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domestic market products, and because there are no local consumers for whom prices should be kept low (Bates, 1981).

[10] Another possible explanation is that government preferences exhibit loss aversion (Tovar, 2009) and therefore tend to protect especially the sectors where profitability is on the decline.

[11] In some countries, these '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.

since the mid-1990s. The nature of the changes in market structure 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. Delpeuch and Leblois (2011) show that, while an increasing number of markets have become competitive, 50 percent of production in SSA still originates from markets with fixed prices. Schematically, former British colonies in ESA (plus Nigeria in WCA) have implemented far-reaching reforms up to the mid-1990s and former French colonies in WCA have introduced much more modest reforms, if any, in the course of the 2000s.

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 as a result of different private sector responses to reform and public and private introduction of new regulations (Delpeuch and Leblois, 2011). 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, forthcoming). In addition, non-historical private ginners have entered and exited the sector on several occasions (Tschirley and Kabwe, 2010). 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 and, in Uganda, regional monopsony rights were established between 2003 and 2008.

Resistance to market reforms has been much stronger in Francophone WCA. The reforms implemented in Benin (1995), Burkina Faso (2004) and Côte d’Ivoire (1994) 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 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 farmer, ginners, transporters and input providers.

In summary, one would expect a stronger impact of reform in ESA than in WCA, where improvements can be expected in relation with potentially better management of the sector, but not from the introduction of competition.

2.3 Market Structure and Performance: Summary Statistics

Figures 1 and 2 describe the evolution of productivity and production as well as market structure, in each of the countries under consideration (in the post-independence period of 1961-2008). A number of trends emerge at the regional level. First, strong output and productivity growth episodes occurred since the 1970s and until the late-1990s to mid-2000s in almost all countries of Francophone WCA (Benin, Burkina Faso, Côte d'Ivoire and Mali as well as Cameroon and Togo to a lesser extent). The only other country where a similar evolution occurred is Nigeria, and it started in the 1980s, after the reform was implemented. In ESA, on the other hand, average yields and output decreased or stagnated at best in the 1970s and 1980s, except in Zimbabwe. The impressive performance of Francophone WCA cotton systems is often attributed to the input provision schemes for cotton cultivation created and enforced by parastatals more widely and earlier than in most ESA countries (they have been in place since the 1950s in WCA) (Baffes, 2005). In addition, with the exception of Zimbabwe, cotton boards in ESA suffered a rather bad reputation with respect to efficiency (Tschirley *et al.*, 2009). On the contrary, there is evidence that, even if they taxed farmers, WCA governments were at least partially using the collected funds for research and extension, as well as the development of infrastructure, hereby improving efficiency (Townsend, 1999).

With regard to the last two decades, during which most reforms were implemented, the picture is less clear. In WCA countries, productivity has fluctuated between stagnation, slow growth and decline, notably in Benin and Côte d'Ivoire. Elsewhere, reforms seem to have boosted productivity in Nigeria, Malawi and Zambia (with a lag) as well as in Tanzania and Uganda (to a lesser extent). Zimbabwe, where productivity has shrunk, is an exception in this region. Output growth, on the other hand, has remained positive in most WCA countries until the early 2000s or the beginning of reforms in Benin and Côte d'Ivoire. Output seems to have been positively impacted by reforms in Mozambique, Nigeria Tanzania, Zambia and Zimbabwe.

3. Empirical Framework and Identification Strategies

3.1 Baseline Model Specification

We develop an econometric analysis to test whether market structure can account for the diverging patterns in cotton performance (output and yields). Our difference-in-difference framework includes a number of controls to account formally for the four possible sources of variation in supply response identified above, namely: the particularity of cotton cultivation, the nature of post-reform market structure, the nature of pre-reform state intervention and external forces.

The sectoral level of our analysis deals with the first of these elements. The nature of post-reform market structure is captured by using market structure indicators, which characterize the degree of competition attained post-reform, rather than simply differentiating between pre- and post-reform. The nature of pre-reform intervention is captured by differentiating between former French colonies and other countries. While an imperfect policy measure, this captures the fact that cotton was given a special role in former French colonies where governments invested more in research and extension than their counterparts. Such investment is believed to have enduring effects even in more recent periods where the difference in terms of investment is less clear (Tschirley *et al.*, 2009). Additional determinants which vary on a timely basis (such as the world prices of cotton and inputs) or on a geographical basis (such as the intrinsic quality of soil for cotton cultivation or the fact to be a landlocked country) are captured in year and country fixed effects. Finally, we incorporate indices of weather conditions as well as data on exchange rate and armed conflicts as additional controls.

The baseline equation to be estimated is then:

$$Log(Y_{it}) = \beta_0 + \beta_1 I_{it} + \beta_3 C_{it} + \gamma_t + c_i + \varepsilon_{it} \qquad (1)$$

where Y_{it} is performance (yields or output) in country i and year t; the βs are parameters to be estimated; the terms I and C stand, respectively, for vectors of institutional variables (the market structure indices) and additional time- and country-specific controls (notably the weather conditions indices); γ_t, and δ_i are the country and year fixed effects and ε_{it} is the error term.

3.2 Variable Choice and Data Sources

3.2.1 Dependant variables

While productivity is a better indicator of performance, the size of the sector is also an interesting one in this case. Indeed, the strong dependence of a number of SSA economies on cotton production and export means that reforms cannot be envisioned without contemplating their short to medium term effect on output. This probably explains why, surprisingly, there is very little evidence of reform impacts on productivity, with the great majority of studies focusing on production (Akiyama *et al.*, 2003).

Data for production (000 Tons), area (000 Ha) and yields (Kg/Ha) is available from the Food and Agriculture Organization of the United Nations (FAO) as well as from the International Cotton Advisory Committee (ICAC) for the years 1961-2008. The FAO data are reported in seed cotton terms whereas the ICAC data is reported in cotton lint terms. As the impact of weather conditions is likely to be more directly perceivable in seed cotton terms, we primarily use the FAO data.[12] The ICAC data is however used to perform data quality robustness checks. Our panel thus comprises the 16 SSA countries for which both the FAO and the ICAC provide data.[13] These countries correspond to the 13 biggest producers of rain-fed cotton in SSA between 1998 and 2008 (Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Mali, Mozambique, Nigeria, Tanzania, Togo, Uganda, Zambia and Zimbabwe), plus Malawi, Kenya, and Senegal. Cameroon, Chad, Mali and Senegal retained monopolistic cotton markets until 2008 and therefore constitute the control group in the most recent years when all other countries introduced reforms.

3.2.2 Market structure

The institutional variables are taken from a database constructed in a companion paper (Delpeuch and Leblois, 2011), which provides precise and consistent market organization indices for 25 African cotton markets from 1961 to 2008. The first variable used, *Post Reform*, is simply a dummy variable that takes on the value one when the traditional monopolistic market organization is abandoned for any other market organization system. The default category, pre-reform, is thus always a monopolistic market in which a single firm (at least partly public) enjoys both a monopoly on exports and a monopsony on buying raw cotton from farmers at a fixed price. The most interesting

[12] Cotton lint is obtained through the ginning process which separates the cotton lint from the cotton seed. The ratio of lint to seed cotton is known as the ginning outturn ratio. Measures of performance in lint terms being affected by the evolution of the ginning outturn ratio, the effect of weather conditions is likely to be less clear.

[13] Following Schlenker and Lobell's (2010) presumption that missing data are replaced by the observation for the previous year, we excluded observations from the estimation if a country had several consecutive years with identical yields (less than 1 percent of observations). Our regressions also exclude pre-independence observations in countries where independence was gained post-1961 as we lacked sufficient information to adequately characterize market structure in the pre-independence period. Our panel thus has 694 observations. Regressions have also been run including the excluded observations, with negligible effects on results.

variables are a set of binary dummy variables used instead of *Post Reform*, which characterize the nature of market organization post-reform. Three dummies allow differentiating between three types of liberalized markets: *Regulation*, which implies that firms operate as regional monopsonies or that supply is administratively allocated among firms; *Low Competition*, which means that two or three firms with large market shares exert price leadership; and *Strong Competition*, which indicates that many firms compete on prices. Given evidence that the impact of reforms might only show up with delays because of slow reform implementation, we also test the impact of these institutional variables with a lag of one or two periods.

3.2.3 Weather conditions

Our indices of weather conditions comprise a measure of total precipitations and one of the length of the rainy season. Both are based on the dataset provided by the Climatic Research Unit of the University of East Anglia (2011), which reports monthly cumulative precipitations for the years 1961-2009 on a 0.5 degree grid. Following Schlenker and Lobell (2010), *Rainfall* is defined as the average cumulative rainfall during the cotton growing season, over all grid cells falling in a country's boundaries, weighted by the share of cropland dedicated to cotton cultivation in each grid cell.[14] The onset and offset of the growing season are defined, as in Blanc *et al.* (2008), by fixed percentages of annual rainfall. This *Rainfall* variable thus represents cumulative rainfall during the cotton season (in thousands of millimeters) within the cotton cultivation areas. It is expected to impact yields mostly in the Sahelian countries of our sample (Mali and Burkina Faso) and in the countries of the South African agro-ecological zone (Malawi, Mozambique, Zambia and Zimbabwe), where drought is a major constraining factor. We therefore use it in interaction with dummy variables for those two zones (*Sahelian* and *South*). The square of *Rainfall* is also included for the Sahelian countries where we expect a decreasing marginal effect of precipitations (Blanc *et al.*, 2008).[15] In countries with a Guinean climate (Benin, Cameroon, Chad, Côte d'Ivoire, Nigeria, Senegal and Togo) and in the eastern zone of

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[14] The shares of cropland dedicated to cotton cultivation are taken from Monfreda et al. (2008). They are based on the potential for cotton cultivation for the year 2000. See Figure 3 for the 5 minutes (~10km) resolution map of the densities used and the annual cumulative rainfall. The major limitation associated to the use of this 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 there therefore affect our estimation only marginally.

[15] In the sub-tropical countries of Eastern Africa, the effect of cumulative precipitations is much more limited. Identifying the potential non linearity of this effect is thus not possible.

East Africa (Kenya, Uganda, Tanzania), we use the length of the rainy season (*Length*) instead of *Rainfall* since total precipitations are less of a limiting factor but the timing of precipitation greatly matters (Sultan *et al.*, 2010). Again, *Length* is used in interaction with regional dummies to account for a different impact of the variable in the two different agro-ecological zones (*Guinean* and *East*). We also include the square of *Length*, expecting decreasing returns. Table 9 and Figure 4, in the Annex, provide summary statistics characterizing precipitations in these four agro-ecological zones.

3.2.4 Other controls

To account for the macroeconomic environment, we include the exchange rate against the dollar, in which cotton is traded internationally. This allows controlling for the different impact of world cotton and input prices across countries, depending on their macroeconomic situation. The fluctuation of the dollar value of the CFAF, the currency of several WCA countries, which is pegged to the euro, is, for example, said to play a key role in the profitability of cotton production in the region. 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.

We also include dummy variables to control for the effect of conflicts, which can disrupt production (e.g. Kaminski *et al.*, 2011, on the implications of the recent Ivorian crisis for cotton production). The data are taken from the UCDP/PRIO Armed Conflict Dataset (2009).[16]

4. Results

4.1 Baseline Model Results

The results of our baseline equation are given in Tables 1, 2 and 3. In Table 1, the institutional vector (*I*) includes only *Post Reform*. Columns (1) to (3) report results of regressions on yields and columns (4) to (6) the results of regressions on production. For each dependant variable, we test the immediate impact of the institutional variables as well as their impact lagged by one and two periods (*I* lag and *I* lag2). Results in Table 1 show that, *ceteris paribus*, the level of productivity was higher in

[16] Three binary dummy variables are included, 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, Type 1, is excluded as it refers to conflicts occurring between a state and a non-state group outside its own territory.

liberalized markets than in monopolistic markets (by 26 percent).[17] No meaningful and significant impact on production is found.

Table 2, however, nuances this first finding. In this table, we enrich the institutional vector with an interaction term between *Post Reform* and a dummy for former French colonies (*Ex-French Col.*). As mentioned above, there are reasons to believe that reforms in this region could have had a particular impact given the different regulation system adopted post-reform. This intuition is verified in Table 2, which reveals that the effects of reforms have been significantly different in Francophone WCA and other countries. In the regulated markets of Francophone WCA, the level of productivity was not significantly different, on average, from the level of productivity in monopolistic markets. The inclusion of the interaction term also shows that the positive difference between productivity levels in liberalized markets in the rest of SSA and in monopolistic markets was bigger than estimated in Table 1 (36 percent instead of 26). On the other hand, while no significant impact of *Post Reform* was found on production in Table 1, Table 2 shows that this is true only for ESA and non-Francophone WCA. Conversely, regulated markets of Francophone WCA produced, on average, twice as much as monopolistic markets. Interestingly, in the two regions, the impact of market structure on production seems to be declining with time (magnitude and significance), while, conversely, the effect on productivity increases with lags.

Table 3 allows refining these results further. With the findings of Table 2 in mind, we couple *Regulation* with *Ex-French Col.* Similar distinctions are not necessary for *Low Competition* and *Strong Competition* as none of the Francophone WCA countries have introduced competition. What Table 3 shows in addition to the two preceding tables is that in ESA and non-Francophone WCA, where a variety of reform options have been adopted, the effect of reforms on yields has varied in magnitude with the type of reform. Productivity was higher by a bit less than 30 percent in moderately competitive markets of ESA than in monopolistic markets, by 40 percent in strongly competitive markets and by about 60 percent in regulated markets (Table 3, column 1).[18]

Collectively the results of Tables 1, 2 and 3 paint a consistent picture. First, it appears that the impact of market structure is meaningful and significant and varies by measure of performance (productivity vs. production), by region, and by type of reform. This suggests that disaggregating the

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[17] As the dependent variables in our regressions are log transformed, the figures we report and comment upon in the text for institutional dummies are computed following Kennedy (1981).

[18] These effects are of comparable magnitude to those identified, in Zambia, by Brambilla and Porto (forthcoming).

impact of reform is necessary to capture the complexity of the relation between market structure and performance. Three things need to be explained: the divergence of results in the two regions, the opposite direction of results by measure of performance and the varying magnitude of effects with different market structures.

In ESA and non-Francophone WCA, production levels do not seem to have been higher in any of the liberalized markets compared to monopolistic markets – if anything; it has been rather lower. Productivity on the other hand has been higher in all types of liberalized markets. This implies that areas under cultivation were lower in liberalized markets and probably that some farmers exited production. This is contrary to expectations of price-induced production incentives boosts. Such results, however, can be explained by the context of cotton production in SSA. First, as explained above, it is likely that competition reduces the sustainability of input credit schemes. If, post-reform, input access on credit is reduced, farmers will likely exit cotton production or produce with much lower yields. We interpret the fact that productivity has been significantly higher in all types of sectors post-reform compared to monopolistic markets as an indication that farmers quit cotton production when input availability declines rather than continue producing with lower yields. Higher productivity in post-reform markets in ESA is therefore likely to be partially a side-effect of market exit, or, put otherwise, the result of a selection process. Alternatively, in moderately competitive markets where input credit systems were maintained, productivity may also have been improved thanks to better input provision by private ginners to targeted farmers as opposed to larger-scale, but not well targeted, distribution of inputs by poorly efficient marketing boards (Brambilla and Porto, forthcoming).

Second, it is not surprising that the price-induced supply response of farmers who continued to produce cotton did not significantly exceed the negative effect of market exit on production as the price effect of reforms was on average relatively limited (Delpeuch *et al.*, 2010). Indeed, monopolistic markets have not always resulted in heavy taxation. Poulton and Delpeuch (2011) for example describe how, in Zimbabwe, cotton taxation was moderated by efforts to encourage smallholder households to enter cotton production post-Independence. In addition, their measures of agricultural distortions to the cotton sector show that taxation began to be reduced before cotton reforms were introduced, through other structural adjustment policies (mainly through the moderation of exchange rate distortions).

In Francophone Africa, the picture is entirely different. The fact that regulated systems are characterized by much higher production than monopolistic markets suggests that the entry of private ginners and the re-organization of markets have contributed to improve production incentives. This possibly occurred through the creation of a pressure to increase producer prices as producers entered the regulation bodies; through greater credibility over prompt payment; and/or easier access to input credit. In a context of credit and input scarcity, the 'institutionally privileged' situation of cotton farmers in this region indeed encourages farmers to produce a small amount of cotton to access inputs, even though they do not have a strong comparative advantage in cotton cultivation. The very stark difference between the effects of regulations in Francophone Africa and elsewhere is a reflection of the very different nature of the types of regulations adopted. As underlined by Tschirley *et al.* (2009 and 2010), in Mozambique and in Uganda, regulation never prevented input credit default crises and stark disturbances in input provision, whereas interlinked transactions have never been challenged in Francophone WCA where private operators are strictly forbidden to compete for the purchase of raw cotton.

The fact that regulated sectors in Francophone WCA however fail to exhibit meaningfully higher productivity (Table 3, equation 1) suggests that reforms have failed to trigger technical change on a large scale. As suggested by Brambilla and Porto (forthcoming), such average effect could however hinder variation at the household level. As much as higher production was the result of market entry by new less experienced farmers using less fertile land, their lower productivity is likely to have weakened national averages. Stagnating yields would therefore indicate that the most productive farmers have improved their productivity post-reform, but that this improvement has been cancelled out by the entry of less productive farmers in cotton cultivation.

Other parameters in Table 1, 2 and 3 have the expected signs. The length of the rainy season has a positive and marginally decreasing impact on yields while cumulative rainfall has a positive impact in the South zone of Southern Africa and a non-linear convex impact in the Sahelian zone. Conflicts of type 3 and 4 have a significant and meaningful negative impact on production (which is lower by 41 percent when a conflict of Type 3 occurs and by 63 percent in the case of a Type 4 conflict) and on productivity (which is then lower by 47 percent in the case of a Type 4 conflict). The exchange rate also has a significantly negative impact on yields (a 1 percent increase in the exchange rate results in a 2 percent decline in yields). This is most likely due to the fact that, as the dollar value of a currency decreases, inputs become more expensive.

4.2 Robustness Checks

The next step is to check the robustness of these findings to alternative specifications and data sources. Table 8, in the annex, reproduces the baseline results using ICAC data for yields and production, instead of FAO data. All the parameters of interest are of similar signs and magnitude. More importantly, we now turn to discussing potential serial correlation, reverse causality and endogeneity.

Bertrand *et al.* (2004) showed that serial correlation causes difference-in-difference standard errors to understate the standard deviation of the estimated treatment effects thus leading to overestimation of *t*-statistics and significance levels. To check that our results do not suffer from such bias, we follow their strategy of "ignoring time series information". We start by regressing log (Y_{it}) on country and year fixed effects as well as our additional vectors of covariates (*C*). We then obtain the effect of the market structure variables and their standard errors from a second OLS regression on the residuals, which now form a two-period panel (with pre-reform being characterized by *Monopoly*, the default category, and post-reform corresponding to either *Post Reform* or *Regulation*, *Low competition* and *Strong competition*). We estimate the two following equations:

$$Log(Y_{it}) = \beta_0 + \beta_1 C_{it} + \gamma_t + c_i + \varepsilon_{it} \qquad (2)$$

$$Residuals_{it} = \beta_0 + \beta_1 I_{it} + \varepsilon_{it} \qquad (3)$$

where *Residuals* are the residuals from equation (2). The results of the second regressions are displayed in Tables 4 (yield) and 5 (production). Both the significance and the signs of the institutional variables (the post-reform variable as well the disaggregated market structure indices) are very much in line with those found with the baseline specification. Two differences, however, are worth noting. First, whereas yields are still found to be higher in liberalized markets of ESA and non-Francophone WCA, this effect is of lower magnitude and it is not significant anymore in moderately competitive markets. Second, whereas production is still found to be higher in liberalized markets of Francophone WCA, the effect is a bit lower. More interesting is the fact that production is found to be significantly lower in strongly competitive markets in ESA and non-Francophone Africa. This suggests that in strongly competitive markets, the production reduction induced by market exit has exceeded the price and productivity-induced production boost among the most efficient farmers. This finding is consistent with the finding by Delpeuch *et al.* (2010), that input distribution on credit – and hence participation in cotton cultivation on a large scale – is likely to be more compromised, the higher the degree of competition.

Second, it could be argued that selection into reform (and thus market structure) was all but random and that poorly performing countries were compelled to introduce reforms when performance deteriorated. A number of prima facie evidence elements however suggest that reform implementation has not been directly linked to market performance. Figures 1 and 2 plot yields and production against market structure. They suggest that (i) reforms took place in very different performance contexts (yields and production trending upwards in Benin for example while they were trending downwards in Zimbabwe) and (ii) countries with relatively similar performance have/have not adopted reforms (e.g. Burkina Faso and Mali in the early 2000s). It is to be expected that reforms have rather been influenced by the macroeconomic and political situation of countries and, most importantly, by the way in which international financial institutions (IFI) promoted structural adjustment plans. Additional evidence that reforms were driven by IFI specific determinants rather than country and cotton sector-specific determinants, can be seen from the fact that reforms happened almost at the same time (1994 or 1995) in most countries of ESA. Conversely, in WCA, competition has been seldom introduced, partly because the French co-operation agency (the *Agence Française de Développement*) played an important role in the reform process – or rather, in the non-reform process – as it opposed the reform agenda pushed forward by the World Bank and promoted or supported regulatory systems instead (Bourdet, 2004).

The fact that reforms were more ideological than market-driven however suggests a potential endogeneity problem: what we capture as being the effect of cotton market reforms could reflect the impact of structural adjustment more generally. To deal with such potential endogeneity and address formally the reverse causality issue, one would ideally like to instrument the reforms. To our knowledge, there is, yet, no suitable instrument to do so. Instead, we try to include as an extra control in our baseline regressions 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, Table A1) 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.[19] However, the fact of having adopted a structural adjustment plan is a neither meaningful nor significant determinant of production, whatever the definition of the variable used. With respect to yields, a small negative and significant impact is found. The inclusion of this variable therefore slightly reinforces the magnitude of the impact of our variables of interest contained in *I* on

[19] See Swinnen et al. (2010, Table A1) for data sources.

agricultural productivity but the signs of the coefficients and their significance are not affected. Overall, the inclusion of a dummy variable that takes on the value one after a structural adjustment plan has been adopted thus suggests that the effect of cotton reforms is not a by-product of structural adjustment more generally. The inclusion of the exchange rate also contributes to controlling for the more general influence of macro-economic reforms.

In addition, we attempt to detect potential reverse causation in two ways. First, we look at whether productivity impacted the probability to implement a reform (Table 6). To do this, we regress the variable *Reform*, which is set to one the year of reform (i.e. the first year during which a sector is not a monopoly anymore), on *Log* (*Yields*), the latter being instrumented by the weather conditions indices. The instruments explain more than 30 percent of yield variations. However, as we expected, no reverse causality is identified through this instrumental variable strategy (column 1) even when using lagged yield and weather conditions indices (column 2).

Second, we compare the coefficients of the lead and lags of *Post Reform* (by two and five years) with the original coefficients displayed in Table 1. We find that the leads of the yield variable are not significant but that the lags are, hence providing at least some degree of protection against potential reverse causation.

5. Concluding Remarks

This paper estimates the impact of market structure on the performance of cotton markets, both in terms of output and productivity. We find that market structure is a meaningful and significant determinant of market performance and that the impact of changes in market structure has been very different in Francophone WCA and in the rest of SSA. In Francophone WCA, regulated sectors have produced more cotton than monopolistic sectors, but yields did not meaningfully increase. Elsewhere in SSA, liberalized markets have produced with higher yields, but highly competitive markets seem to have produced less than monopolistic markets. We believe that the main factor behind the differences in reform effects in Francophone WCA and elsewhere in SSA is the nature of reforms.

To our knowledge, quantitative estimations of the effects of cotton marketing reforms had never been done, except in two country case studies. Looking at the Zambian reform experience, Brambilla and Porto (forthcoming), found that production and productivity both declined in the aftermath of reform, at a time of strong competition when the input-credit system was challenged. Both however recovered when cooperation between firms improved and the input-credit scheme was revived (albeit at the cost of lower competition). Our results are coherent with these findings in as much as we also find a negative impact of reform on production in strongly competitive markets, but none in less competitive markets. However, regarding productivity, we find that, on average, it has been greater in strongly competitive markets and in regulated markets than in moderately competitive markets. Our results therefore suggest that, where input credit systems have been challenged, stricter selection of the most productive farmers seems to have had more of an impact on average productivity than the gains linked to better quality input distribution in moderately competitive markets. The difference between our findings and those by Brambilla and Porto, however, is not surprising. The Zambian reform experience is often considered as the most successful in ESA (e.g. Tschirley *et al.*, 2009). It could therefore be that (i) there was less market exit in Zambia than in other competitive sectors on average – hence that the increase in average yield due to the selection effect was lower during the strong competition period – and (ii) that the gains in productivity obtained through reform via better quality input distribution during the moderate competition period in this country were more important.

The other case study, by Kaminski *et al.* (2011) looks at the Burkinabe reform experience. The authors find that the reform participated in boosting production, at the cost of state transfers needed to maintain high producer prices. Our results are consistent with this finding and underline another hidden cost of this reform: the non-improvement of productivity due the absence of increased selection into cotton cultivation. The apparent contradiction between the results of this study and that by Brambilla and Porto is explained by the different nature of post-reform market structure.

Overall, this paper clarifies what should be expected out of the introduction of increased competition. This paper suggests that too much competition is not likely to improve production, on the contrary. Introducing far-reaching reforms in Francophone WCA would thus likely have a detrimental effect the revenues of the least productive farmers and, hence, on poverty rates, given the significance of cotton as a source of income for rural populations in these countries. This paper however also clearly demonstrates the price of cotton cultivation expansion in terms of efficiency in the latter region. In a perspective of poverty-reduction and rural development, the balance remains to be found between producing more cotton and producing cotton more efficiently.

Ironically enough, the key conclusion of this paper might thus be that market organization of the sector cannot alone promote output growth and productivity. In this perspective, attention may have to be shifted away from cotton-only reforms towards re-invigorating agricultural policies as a whole. The creation of innovative input access mechanisms and of efficient (and targeted) social safety-nets which would not be tied to the production of one particular crop appears as a priority.

Finally, this paper illustrates the interest of looking at the impact of structural adjustment in African agriculture in a difference-in-difference framework using precise institutional variables. Additional work on the effects of reforms in particular countries, building on household level data (for example along the lines of the forthcoming study by Brambilla and Porto) would contribute to a better understanding of the mechanism underlying the trends identified in this paper which reflect average effects. In such a framework, instrumenting reforms might be easier and help control more formally for potential endogeneity problems.

6. References

AKIYAMA, T., J. BAFFES, D. LARSON, and P. VARANGIS (2003). "Commodity Market Reform in Africa: Some Recent Experience." Economic Systems, 27, pp. 83-115.

ANDERSON, K. and W.A. MASTERS (Eds.) (2009). *Distortions to Agricultural Incentives in Africa*, Washington DC: World Bank

ARAUJO BONJEAN, C. and J.-L. COMBES (2003). "Preserving vertical co-ordination in the West African cotton sector." Working Paper 200303, CERDI.

BAFFES J (2007). "Distortions to cotton Sector Incentives in West and Central Africa." Presented at the CSAE conference *Economic Development in Africa*, March 19-20, Oxford.

BAFFES, J (2005). "The 'Cotton Problem'." *The World Bank Research Observer*, *20* (1), pp. 109-144.

BAGHDADLI I., H. CHEIKHROUHOU and G. RABALLAND. 2007 "Strategies for cotton in West and Central Africa: enhancing competitiveness in the "Cotton 4"", The World Bank.

BATES, R. H. and S. BLOCK (2009). "The political Economy of Agricultural Trade Interventions in Africa." World Bank Agricultural Distortions Working Paper No. 87.

BERTRAND, M., E. DUFLO and S. MULLAINATHAN (2004). "How Much Should We Trust Differences-In-Differences Estimates?" *The Quarterly Journal of Economics*, *119*(1), pp. 249-275.

BLANC, E. P. QUIRION and E. STROBL (2008). "The climatic determinants of cotton yields: Evidence from a plot in West Africa." *Agricultural and Forest Meteorology*, *148* (6-7).

BOURDET, Y. (2004). "A tale of Three Countries – Structure, Reform and Performance of the Cotton Sector in Mali, Burkina Faso and Benin." Sida Country Economic Report 2004:2.

BRAMBILLA, I. and G. PORTO. (Forthcoming). "Market Structure, Outgrower Contracts and Farm Output. Evidence from Cotton Reforms in Zambia." Forthcoming in *Oxford Economic Papers*.

UNIVERSITY OF EAST ANGLIA CLIMATIC RESEARCH UNIT Database. http://www.cru.uea.ac.uk/ (accessed May, 2011).

DELPEUCH, C and A LEBLOIS (2011). "Sub-Saharan African Cotton Policies in Retrospect." GEM-CIRED Working Paper, Sciences Po, Paris

DELPEUCH, C., A. VANDEPLAS and J. SWINNEN (2010). "Revisiting the 'Cotton Problem': A Comparative Analysis of Cotton Reforms in Sub-Saharan Africa." Paper prepared for presentation at *3rd AAAE & 48th A.E.A.S.A Conference* (Cape Town, September 19-23).

DORWARD, A., J. KYDD AND C. POULTON (2004). "Market and Coordination Failures in Poor Rural Economies: Policy Implications for Agricultural and Rural Development." Presented the AAAE Conference Shaping the future of African Agriculture for Development : The Role of Social Scientists, 6 to 8 December, Nairobi.

FAOSTAT Database (2011). United Nations Food and Agriculture Organization, Rome. http://faostat.fao.org/ (accessed May, 2011).

FONTAINE, B., and S. JANICOT. 1996. "Sea surface temperature fields associated with West African rainfall anomaly types." *Journal of Climate*, 9 (11), pp. 2935-2940.

HESTON, A. R. SUMMERS and B. ATEN (2010). Penn World Table Version 7.0, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania: http://pwt.econ.upenn.edu/php_site/pwt_index.php (accessed May, 2011).

INTERNATIONAL COTTON ADVISORY COMMITTEE Database, Washington D.C. www.icac.org/ (accessed May, 2011).

JAYNE, T.S., J. D. SHAFFER, J. M. STAATZ, and T. REARDON. 1997. "Improving the Impact of Market Reform on Agricultural Productivity in Africa: How Institutional Design Makes a Difference." Michigan State University International Development Working Papers No. 66.

KASARA, K (2007). "Tax Me If You Can: Ethnic Geography, Democracy and the Taxation of Agriculture in Africa." *American Political Science Review* 101(1): p.159-172

KAMINSKI, J., D. HEADEY and T. BERNARD (2011). "The Burkinabè Cotton Story 1992-2007: Sustainable Success or Sub-Saharan Mirage?" World Development (article in press).

KHERALLAH, M., DELGADO, C., GABRE-MADHIN, E., MINOT, N., M. JONSON (2002). Reforming Markets in Africa. Baltimore and London: The John Hopkins University Press.

KRUEGER, A., M. SCHIFF and A. VALDES. 1988. "Agricultural incentives in developing countries - measuring the effect of sectoral and economy-wide policies." *World Bank Economic Review* 2(3): p.255-272

LE BARBÉ, L., T. LEBEL, and D. TAPSOBA. 2001. "Rainfall variability in West Africa during the years 1950-1990." *Journal of Climate, 15* (2), pp. 187-202.

MEERMAN, J. P. 1997. "Reforming Agriculture: The World Bank Goes to Market."

MONFREDA, C., N. RAMANKUTTY, and J. A. FOLEY (2008). "Farming the planet: Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000." *Global Biogeochemical Cycles,* 22, pp.1–19.

NUBUKPO K.K. and M. S. KEITA (2005). "Reform of the fixing mechanism for the purchase price for Malian cotton farmers and its consequences in the context of falling world prices," in E. Hazard, ed., *International trade negotiations and poverty reduction: The white paper on Cotton.* Dakar: ENDA.

OLSON, M. 1985. "Toward a More General Theory of Governmental Structure." *Papers and Proceedings of the Ninety-Eighth Annual Meeting of the American Economic Association, 76* (2), pp. 120-125.

POULTON, C. and C. DELPEUCH (2011). "Not Ready for Analysis? A Critical Review of NRA Estimations for Cotton and Other Export Cash Crops in Africa." Under Review.

ROY, A (2010). "Peasant struggles in Mali: from defending cotton producers' interests to becoming part of the Malian power structures." *Review of African Political Economy, 37,*(125) pp. 299 – 314.

ROZELLE S. and SWINNEN J.F.M (2004). "Success and failure of reform: Insights from the transition of agriculture." *Journal of Economic Literature, 42* (2), pp. 404–456.

SCHLENKER, W. and D. B LOBELL (2010). "Robust negative impacts of climate change on African agriculture." Environmental Research Letters, 5 (1)

SWINNEN, J. F. M (2010). "The Political Economy of Agricultural and Food Policies: Recent Contributions, New Insights, and Areas for Further Research." Applied Economic Perspectives and Policy, 32 (1), pp. 33–58.

SWINNEN, J. F. M., VANDEPLAS, A., MAERTENS, M (2010). Liberalisation, endogenous institutions, and growth: a comparative analysis of agricultural reforms in Africa, Asia, and Europe. *The World Bank Economic Review, 24* (3), pp. 412-445.

SWINNEN, J. F. M. and L. VRANKEN (2010). Reforms and agricultural productivity in Central and Eastern Europe and the Former Soviet Republics: 1989–2005." *Journal of Productivity Analysis, 33* (3), pp.

SULTAN, B., M. BELLA-MEDJO, A. BERG, P. QUIRION and S. JANICOT (2010). “Multi-scales and multi-sites analyses of the role of rainfall in cotton yields in West Africa.” *International Journal of Climatology, 30*, pp. 58–71.

TOVAR, P. 2009. “The effects of loss aversion on trade policy: Theory and evidence.” *Journal of International Economics*, *78* (1), pp. 154-167.

TOWNSEND, R.F. 1999. “Agricultural Incentives in Sub-Saharan Africa. Policy Challenges.” World Bank Technical Paper No. 444.

TSCHIRLEY, D, C POULTON and P LABASTE (Eds) (2009). Organization and Performance of Cotton Sectors in Africa: Learning from Reform Experience. Agriculture and Rural Development series. Washington DC, World Bank.

UCDP/PRIO Armed Conflict Dataset v4-2009. http://www.prio.no/CSCW/Datasets/Armed-Conflict/UCDP-PRIO/ (accessed May, 2011)

WORLD METEOROLOGICAL ORGANIZATION (2010). “Guide to Agricultural Meteorological Practices 2010 Edition”, WMO-No.134.

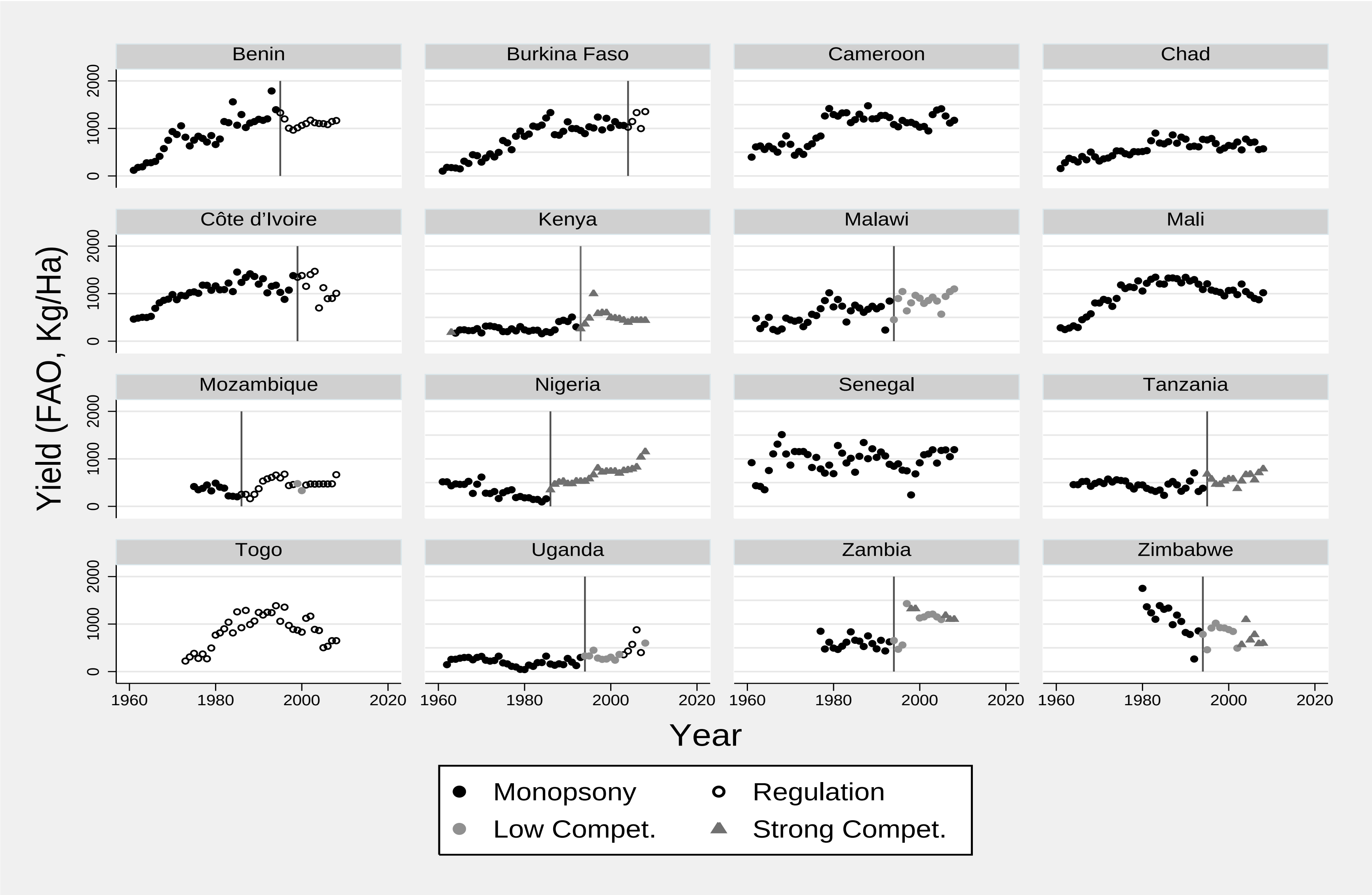

Figure 1: Productivity and market organisation in African cotton sectors after the independances

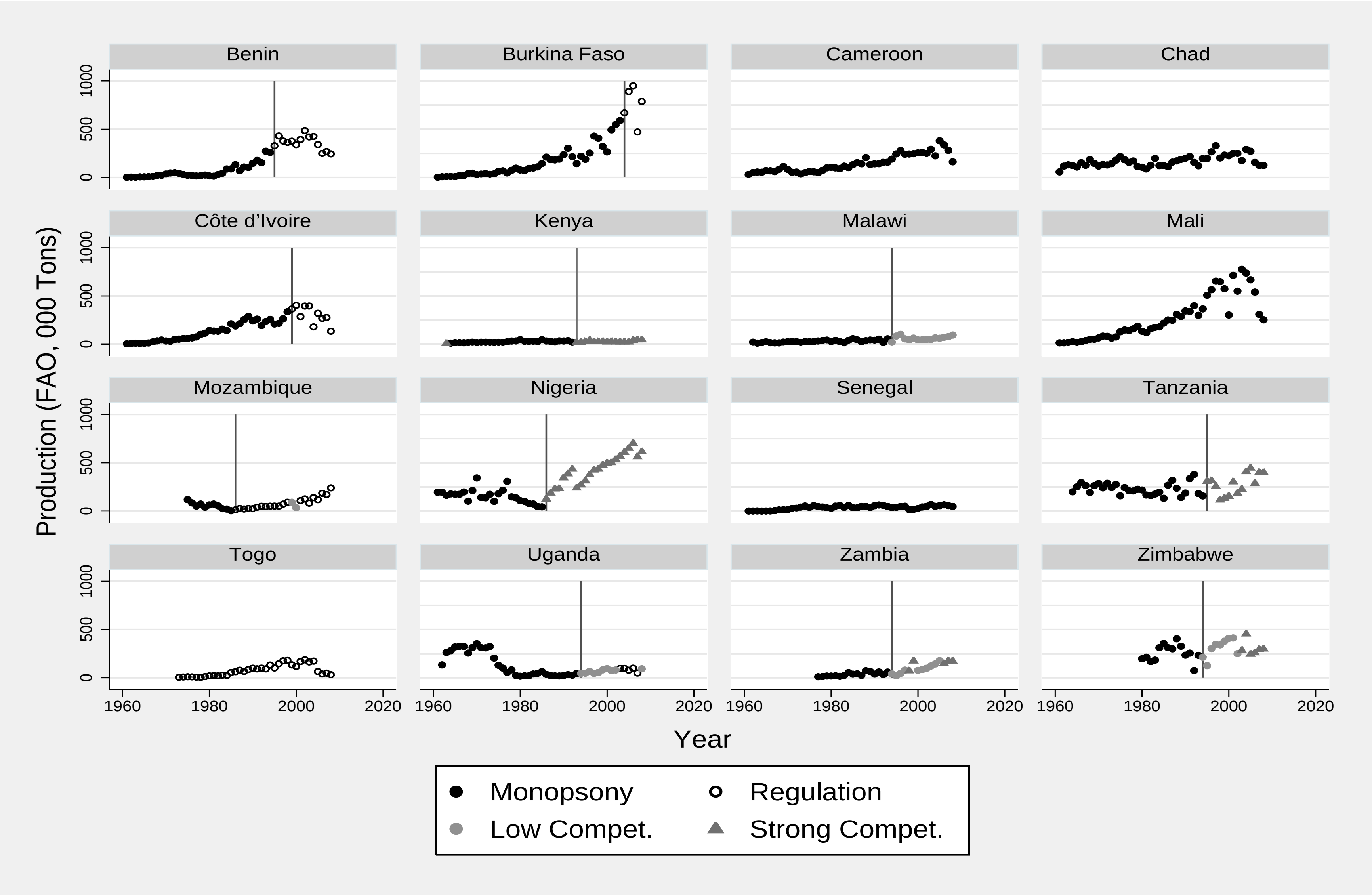

Figure 2: Production and market organisation in African cotton sectors after the independances

Table 1: Cotton market reforms and performance (OLS, year and country FE)

	(1) Log Yield	(2) Log Yield (I lag)	(3) Log Yield (I lag2)	(4) Log Production	(5) Log Production (I lag)	(6) Log Production (I lag2)
Post-Reform	0.238***	0.277***	0.317***	−0.0531	0.00850	0.0183
	(0.0807)	(0.0848)	(0.0893)	(0.281)	(0.275)	(0.265)
Length * Guinean	0.406***	0.462***	0.491***	−0.0727	−0.0922	0.0839
	(0.0856)	(0.0723)	(0.0741)	(0.149)	(0.164)	(0.154)
Length * Guinean (sq)	−0.0423***	−0.0480***	−0.0511***	−0.00731	−0.00889	−0.0225
	(0.00978)	(0.00846)	(0.00870)	(0.0149)	(0.0168)	(0.0164)
Length * East	0.609***	0.644***	0.618***	1.021***	1.018***	0.985***
	(0.116)	(0.0937)	(0.0919)	(0.184)	(0.196)	(0.168)
Length * East (sq)	−0.0351***	−0.0365***	−0.0352***	−0.0554***	−0.0553***	−0.0518***
	(0.00683)	(0.00582)	(0.00559)	(0.0121)	(0.0124)	(0.0113)
Rainfall * Sahelian	−6.161**	−5.811**	−6.025*	−6.513	−6.787*	−6.394*
	(2.431)	(2.410)	(2.843)	(3.836)	(3.691)	(3.531)
Rainfall * Sahelian (sq)	3.895**	3.680**	3.784*	4.050	4.288	4.037
	(1.663)	(1.689)	(1.977)	(2.503)	(2.450)	(2.383)
Rainfall * South	0.454	0.387	0.274	0.255	0.258	0.0846
	(0.276)	(0.260)	(0.240)	(0.534)	(0.529)	(0.484)
Log Xrate	−0.00943	−0.0108	−0.0119	−0.101	−0.102	−0.0979
	(0.0150)	(0.0149)	(0.0157)	(0.0769)	(0.0770)	(0.0745)
Conflict Type2	0.163	0.168	0.144	0.150	0.178	0.173
	(0.226)	(0.217)	(0.220)	(0.273)	(0.261)	(0.257)
Conflict Type3	−0.131	−0.129	−0.117	−0.409*	−0.425*	−0.392
	(0.0889)	(0.0923)	(0.0934)	(0.231)	(0.233)	(0.225)
Conflict Type4	−0.538**	−0.539**	−0.522**	−0.960*	−0.974*	−0.925*
	(0.246)	(0.229)	(0.221)	(0.487)	(0.503)	(0.511)
Constant	4.409***	7.492***	7.889***	−3.764***	4.491***	4.676***
	(0.640)	(0.317)	(0.284)	(0.883)	(0.784)	(0.697)
Observations	694	686	677	694	686	677
R^2	0.696	0.706	0.707	0.697	0.691	0.688
Adjusted R^2	0.660	0.671	0.672	0.661	0.654	0.650

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 2: Cotton market reforms, history and performance (OLS, year and country FE)

	(1) Log Yield	(2) Log Yield (I lag)	(3) Log Yield (I lag2)	(4) Log Production	(5) Log Production (I lag)	(6) Log Production (I lag2)
Post-Reform	0.311^{***}	0.371^{***}	0.417^{***}	-0.442	-0.315	-0.245
	(0.100)	(0.101)	(0.0979)	(0.280)	(0.301)	(0.301)
Post-Reform * Ex-French Col.	-0.228	-0.310^{**}	-0.354^{**}	1.227^{***}	1.064^{**}	0.939^{**}
	(0.135)	(0.141)	(0.142)	(0.396)	(0.411)	(0.412)
Length * Guinean	0.403^{***}	0.460^{***}	0.476^{***}	-0.0552	-0.0859	0.123
	(0.0880)	(0.0752)	(0.0792)	(0.144)	(0.158)	(0.157)
Length * Guinean (sq)	-0.0419^{***}	-0.0477^{***}	-0.0486^{***}	-0.00955	-0.0100	-0.0291
	(0.0100)	(0.00872)	(0.00936)	(0.0144)	(0.0164)	(0.0167)
Length * East	0.594^{***}	0.639^{***}	0.606^{***}	1.100^{***}	1.036^{***}	1.017^{***}
	(0.109)	(0.0868)	(0.0809)	(0.174)	(0.157)	(0.146)
Length * East (sq)	-0.0342^{***}	-0.0359^{***}	-0.0344^{***}	-0.0603^{***}	-0.0573^{***}	-0.0539^{***}
	(0.00641)	(0.00563)	(0.00520)	(0.0113)	(0.0104)	(0.0105)
Rainfall * Sahelian	-6.190^{**}	-5.833^{**}	-5.657^{*}	-6.361	-6.712^{*}	-7.368^{*}
	(2.391)	(2.452)	(2.691)	(3.951)	(3.734)	(3.859)
Rainfall * Sahelian (sq)	3.913^{**}	3.684^{*}	3.544^{*}	3.950	4.277^{*}	4.676^{*}
	(1.652)	(1.744)	(1.919)	(2.508)	(2.394)	(2.499)
Rainfall * South	0.449	0.358	0.242	0.282	0.360	0.171
	(0.273)	(0.245)	(0.219)	(0.562)	(0.589)	(0.529)
Log Xrate	-0.0178	-0.0216^{*}	-0.0233^{*}	-0.0557	-0.0648	-0.0675
	(0.0124)	(0.0116)	(0.0123)	(0.0772)	(0.0788)	(0.0767)
Conflict Type2	0.165	0.171	0.147	0.138	0.170	0.166
	(0.225)	(0.215)	(0.216)	(0.279)	(0.266)	(0.266)
Conflict Type3	-0.117	-0.109	-0.0944	-0.482^{**}	-0.496^{**}	-0.453^{*}
	(0.0900)	(0.0952)	(0.0963)	(0.222)	(0.227)	(0.221)
Conflict Type4	-0.540^{**}	-0.536^{**}	-0.511^{**}	-0.948^{*}	-0.985^{*}	-0.953^{*}
	(0.252)	(0.234)	(0.225)	(0.459)	(0.486)	(0.500)
Constant	4.458^{***}	7.578^{***}	7.973^{***}	-4.029^{***}	4.195^{***}	4.454^{***}
	(0.624)	(0.340)	(0.297)	(0.915)	(0.839)	(0.744)
Observations	694	686	677	694	686	677
R^2	0.699	0.710	0.712	0.717	0.706	0.699
Adjusted R^2	0.662	0.675	0.678	0.683	0.670	0.662

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 3: Cotton market structure, history and performance (OLS, year and country FE)

	(1) Log Yield	(2) Log Yield (I lag)	(3) Log Yield (I lag2)	(4) Log Production	(5) Log Production (I lag)	(6) Log Production (I lag2)
Regulation	0.478*	0.576**	0.589*	−0.451	−0.223	−0.126
	(0.263)	(0.260)	(0.284)	(0.304)	(0.255)	(0.290)
Regulation * Ex-French Col.	−0.395	−0.516*	−0.536*	1.245**	0.981**	0.829*
	(0.277)	(0.272)	(0.290)	(0.431)	(0.387)	(0.404)
Low Competition	0.240*	0.254**	0.328***	−0.421	−0.302	−0.134
	(0.113)	(0.116)	(0.0991)	(0.242)	(0.273)	(0.280)
Strong Competition	0.334**	0.397***	0.397***	−0.409	−0.292	−0.289
	(0.116)	(0.131)	(0.128)	(0.331)	(0.324)	(0.305)
Length * Guinean	0.406***	0.447***	0.474***	−0.0542	−0.0812	0.133
	(0.0891)	(0.0742)	(0.0855)	(0.145)	(0.163)	(0.163)
Length * Guinean (sq)	−0.0421***	−0.0463***	−0.0484***	−0.00978	−0.0104	−0.0300
	(0.0102)	(0.00824)	(0.00988)	(0.0144)	(0.0167)	(0.0173)
Length * East	0.639***	0.758***	0.718***	1.043***	0.970***	0.959***
	(0.140)	(0.150)	(0.150)	(0.189)	(0.196)	(0.172)
Length * East (sq)	−0.0374***	−0.0447***	−0.0422***	−0.0560***	−0.0521***	−0.0498***
	(0.00829)	(0.00925)	(0.00910)	(0.0123)	(0.0129)	(0.0115)
Rainfall * Sahelian	−6.201**	−5.951**	−5.630*	−6.319	−6.592	−7.110*
	(2.431)	(2.512)	(2.724)	(3.969)	(3.793)	(3.958)
Rainfall * Sahelian (sq)	3.919**	3.778*	3.548*	3.913	4.188	4.501
	(1.703)	(1.815)	(1.960)	(2.513)	(2.447)	(2.568)
Rainfall * South	0.476*	0.393*	0.235	0.275	0.394	0.167
	(0.261)	(0.204)	(0.210)	(0.549)	(0.577)	(0.534)
Log Xrate	−0.0193	−0.0219	−0.0217	−0.0568	−0.0674	−0.0721
	(0.0141)	(0.0133)	(0.0130)	(0.0771)	(0.0773)	(0.0756)
Conflict Type2	0.167	0.170	0.142	0.139	0.173	0.172
	(0.230)	(0.222)	(0.220)	(0.279)	(0.267)	(0.267)
Conflict Type3	−0.106	−0.0913	−0.0818	−0.478**	−0.483*	−0.445*
	(0.0910)	(0.0947)	(0.0935)	(0.218)	(0.235)	(0.236)
Conflict Type4	−0.559*	−0.548**	−0.510**	−0.946*	−0.986*	−0.950*
	(0.270)	(0.245)	(0.229)	(0.469)	(0.490)	(0.501)
Observations	694	686	677	694	686	677
R^2	0.701	0.715	0.715	0.717	0.706	0.699
Adjusted R^2	0.664	0.680	0.680	0.681	0.669	0.662

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 4: Ignoring time series information: cotton market structure and productivity (OLS)

	(1) Residuals yield	(2) Residuals yield (I lag)	(3) Residuals yield (I lag2)	(4) Residuals yield	(5) Residuals yield (I lag)	(6) Residuals yield (I lag2)	(7) Residuals yield	(8) Residuals yield (I lag)	(9) Residuals yield (I lag2)
Post-Reform	0.0743**	0.0860***	0.101***	0.0886***	0.105***	0.122***			
	(0.0312)	(0.0314)	(0.0322)	(0.0337)	(0.0338)	(0.0345)			
Post-Reform * Ex-French Col.				−0.0799	−0.109	−0.127			
				(0.0713)	(0.0733)	(0.0772)			
Regulation							0.0668	0.0922**	0.0976**
							(0.0469)	(0.0465)	(0.0474)
Regulation * Ex-French Col.							−0.0562	−0.0932	−0.0990
							(0.0784)	(0.0798)	(0.0837)
Low Competition							0.0382	0.0233	0.0565
							(0.0537)	(0.0529)	(0.0528)
Strong Competition							0.115**	0.142***	0.148***
							(0.0469)	(0.0468)	(0.0478)
Constant	−0.0174	−0.0189	−0.0209	−0.0174	−0.0189	−0.0209	−0.0192	−0.0218	−0.0242
	(0.0151)	(0.0147)	(0.0146)	(0.0151)	(0.0147)	(0.0146)	(0.0157)	(0.0153)	(0.0152)
Observations	694	686	677	694	686	677	694	686	677
R^2	0.008	0.011	0.014	0.010	0.014	0.018	0.011	0.018	0.019
Adjusted R^2	0.007	0.009	0.013	0.007	0.011	0.015	0.005	0.012	0.013

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 5: Ignoring time series information, cotton market structure and production (OLS)

	(1) Residuals prod	(2) Residuals prod (I lag)	(3) Residuals prod (I lag2)	(4) Residuals prod	(5) Residuals prod (I lag)	(6) Residuals prod (I lag2)	(7) Residuals prod	(8) Residuals prod (I lag)	(9) Residuals prod (I lag2)
Post-Reform	−0.0166	0.000632	0.00246	−0.143**	−0.113*	−0.0990			
	(0.0605)	(0.0612)	(0.0622)	(0.0641)	(0.0650)	(0.0660)			
Post-Reform * Ex-French Col.				0.705***	0.662***	0.618***			
				(0.136)	(0.141)	(0.148)			
Regulation							−0.0381	−0.00793	−0.00497
							(0.0893)	(0.0896)	(0.0906)
Regulation * Ex-French Col.							0.602***	0.557***	0.524***
							(0.149)	(0.154)	(0.160)
Low Competition							−0.141	−0.111	−0.0362
							(0.102)	(0.102)	(0.101)
Strong Competition							−0.154*	−0.141	−0.171*
							(0.0893)	(0.0903)	(0.0913)
Constant	0.00387	−0.000139	−0.000510	0.00387	−0.000139	−0.000510	0.00298	−0.000702	−0.000635
	(0.0292)	(0.0287)	(0.0283)	(0.0287)	(0.0283)	(0.0279)	(0.0298)	(0.0294)	(0.0291)
Observations	694	686	677	694	686	677	694	686	677
R^2	0.000	0.000	0.000	0.038	0.031	0.025	0.037	0.032	0.027
Adjusted R^2	−0.001	−0.001	−0.001	0.035	0.028	0.022	0.032	0.026	0.021

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 6: Reverse causality test 1: did productivity influence the timing of reforms? (IV identification strategy)

	(1) Reform	(2) Reform (All lag)
Log Yield	−0.0205	−0.0273
	(0.0806)	(0.0831)
Log Xrate	−0.00150	−0.00132
	(0.00250)	(0.00295)
Conflict Type2	−0.00151	−0.0458
	(0.0491)	(0.0495)
Conflict Type3	−0.00185	−0.0224
	(0.0209)	(0.0202)
Conflict Type4	0.0441	0.0419
	(0.0485)	(0.0489)
Constant	0.216	0.274
	(0.755)	(0.770)
R^2	0.152	0.156
Adjusted R^2	0.061	0.066
	Log Yield	Log Yield (lag) (All lag)
Length * Guinean	0.364*	0.385*
	(0.213)	(0.216)
Length * Guinean (sq)	−0.0378*	−0.0406**
	(0.0198)	(0.0200)
Length * East	0.616*	0.615
	(0.372)	(0.387)
Length * East (sq)	−0.0356	−0.0368
	(0.0229)	(0.0237)
Rainfall * Sahelian	−6.210**	−6.627**
	(2.792)	(2.840)
Rainfall * Sahelian (sq)	3.896**	4.104**
	(1.829)	(1.863)
Rainfall * South	0.440	0.872
	(0.283)	(1.554)
Log Xrate	0.00247	0.00448
	(0.00801)	(0.00951)
Conflict Type2	0.152	0.162
	(0.153)	(0.154)
Conflict Type3	−0.147***	−0.118**
	(0.0560)	(0.0565)
Conflict Type4	−0.482***	−0.467***
	(0.0993)	(0.100)
Constant	4.405***	7.659***
	(1.542)	(0.622)
Observations	694	688
R^2	0.688	0.686
Adjusted R^2	0.651	0.649

Standard errors in parentheses

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

Table 7: Reverse causality test 2: Cotton market reform leads and performance (OLS, year and country FE)

	(1) Log Yield (I lead2)	(2) Log Yield (I lead5)	(3) Log Yield (I lead10)	(4) Log Production (I lead2)	(5) Log Production (I lead5)	(6) Log Production (I lead10)
Post Reform	0.0239	−0.118	−0.264	−0.194	−0.329	−0.273
	(0.112)	(0.158)	(0.163)	(0.354)	(0.355)	(0.324)
Length * Guinean	0.409***	0.315***	0.354***	−0.0505	−0.156	−0.167
	(0.104)	(0.0966)	(0.0876)	(0.199)	(0.165)	(0.161)
Length * Guinean (sq)	−0.0439***	−0.0328***	−0.0364***	−0.0115	0.00143	0.00229
	(0.0117)	(0.0105)	(0.00907)	(0.0205)	(0.0175)	(0.0175)
Length * East	0.600***	0.579***	0.525**	1.215***	1.472***	0.953***
	(0.122)	(0.163)	(0.192)	(0.167)	(0.200)	(0.151)
Length * East (sq)	−0.0353***	−0.0332***	−0.0303**	−0.0660***	−0.0795***	−0.0516***
	(0.00767)	(0.00985)	(0.0115)	(0.0105)	(0.0122)	(0.0101)
Rainfall * Sahelian	−7.096**	−7.256**	−5.992	−8.975**	−7.762*	−5.505
	(2.719)	(3.039)	(3.676)	(3.776)	(3.839)	(4.037)
Rainfall * Sahelian (sq)	4.466**	4.538**	3.780	5.846**	5.116**	3.841
	(1.908)	(2.056)	(2.396)	(2.460)	(2.323)	(2.352)
Rainfall * South	0.447	0.501*	0.513*	0.302	0.135	0.169
	(0.295)	(0.274)	(0.264)	(0.454)	(0.490)	(0.562)
Log Xrate	0.0101	0.0112	0.00787	−0.159	−0.187*	−0.244***
	(0.0200)	(0.0271)	(0.0232)	(0.0914)	(0.0921)	(0.0761)
Conflict Type2	0.164	0.190	0.167	0.152	0.191	0.137
	(0.228)	(0.216)	(0.217)	(0.287)	(0.248)	(0.260)
Conflict Type3	−0.127	−0.163	−0.200*	−0.374*	−0.384**	−0.381*
	(0.0953)	(0.0979)	(0.111)	(0.188)	(0.179)	(0.189)
Conflict Type4	−0.484*	−0.537	−0.629*	−0.932*	−0.987*	−1.171*
	(0.238)	(0.307)	(0.328)	(0.496)	(0.536)	(0.563)
Constant	4.605***	7.743***	4.896***	−3.963***	4.900***	−2.418**
	(0.566)	(0.387)	(0.844)	(0.991)	(0.715)	(0.836)
Observations	664	616	537	664	616	537
R^2	0.694	0.704	0.707	0.712	0.712	0.709
Adjusted R^2	0.657	0.667	0.668	0.677	0.676	0.670

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Annex

Table 8: Data robustness check: key results using ICAC data (OLS, year and country FE) E

	(1) Log Yield ICAC	(2) Log Yield ICAC (I lag)	(3) Log Yield ICAC (I lag2)	(4) Log Production ICAC	(5) Log Production ICAC (I lag)	(6) Log Production ICAC (I lag2)
Regulation	0.548	0.549	0.440	−0.506	−0.171	−0.0778
	(0.451)	(0.373)	(0.311)	(0.453)	(0.388)	(0.410)
Regulation * Ex-French Col.	−0.601	−0.621	−0.522	1.363**	0.981*	0.816
	(0.472)	(0.401)	(0.349)	(0.566)	(0.514)	(0.546)
Low Competition	0.265	0.348*	0.419*	−0.369	−0.220	−0.0975
	(0.195)	(0.196)	(0.197)	(0.324)	(0.363)	(0.342)
Strong Competition	0.113	0.186	0.181	−0.770**	−0.675**	−0.664**
	(0.128)	(0.159)	(0.170)	(0.343)	(0.297)	(0.264)
Length * Guinean	0.131*	0.139*	0.144**	−0.332*	−0.242	−0.215
	(0.0666)	(0.0684)	(0.0533)	(0.167)	(0.210)	(0.225)
Length * Guinean (sq)	−0.0143**	−0.0152*	−0.0159**	0.0206	0.00833	0.00444
	(0.00669)	(0.00716)	(0.00572)	(0.0156)	(0.0207)	(0.0220)
Length * East	0.746***	0.808***	0.764***	1.025***	0.864***	0.865***
	(0.133)	(0.130)	(0.131)	(0.198)	(0.199)	(0.189)
Length * East (sq)	−0.0424***	−0.0463***	−0.0437***	−0.0573***	−0.0482***	−0.0463***
	(0.00796)	(0.00850)	(0.00807)	(0.0122)	(0.0130)	(0.0129)
Rainfall * Sahelian	−6.567*	−6.059*	−5.522*	−7.302*	−7.250*	−7.807**
	(3.177)	(3.092)	(2.821)	(3.583)	(3.414)	(3.599)
Rainfall * Sahelian (sq)	4.083*	3.726*	3.377*	4.358*	4.468*	4.770*
	(1.917)	(1.869)	(1.684)	(2.287)	(2.215)	(2.334)
Rainfall * South	0.306	0.193	0.0971	0.328	0.470	0.286
	(0.288)	(0.245)	(0.242)	(0.527)	(0.541)	(0.473)
Log Xrate	−0.0187	−0.0233	−0.0222	−0.0561	−0.0700	−0.0742
	(0.0163)	(0.0155)	(0.0136)	(0.0903)	(0.0926)	(0.0905)
Conflict Type2	0.176	0.174	0.156	−0.0672	−0.0287	−0.0134
	(0.123)	(0.119)	(0.113)	(0.217)	(0.204)	(0.194)
Conflict Type3	−0.00528	0.0152	0.00776	−0.445*	−0.426	−0.375
	(0.0982)	(0.0962)	(0.0948)	(0.247)	(0.272)	(0.269)
Conflict Type4	−0.346	−0.307	−0.283	−0.703	−0.729	−0.695
	(0.223)	(0.198)	(0.173)	(0.449)	(0.481)	(0.477)
Observations	681	679	673	693	686	677
R^2	0.739	0.742	0.741	0.699	0.694	0.693
Adjusted R^2	0.706	0.709	0.708	0.661	0.656	0.655

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

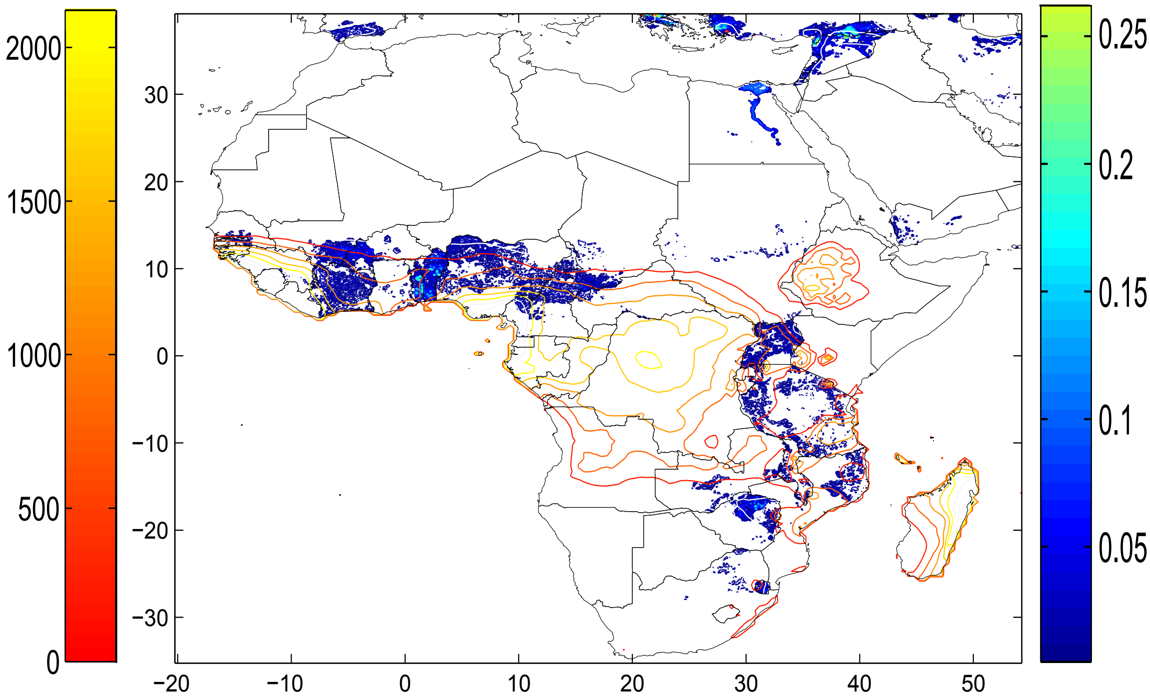

Figure 3: Isohyets (annual cumulative rainfall, lefthand legend in mm) and intensity of cotton cultivation in 2000 (righthand legend in %), Source: CRU TS3.0 (Climate Research Unit, University of East Anglia, 2011) & Monfreda *et al.* (2008).

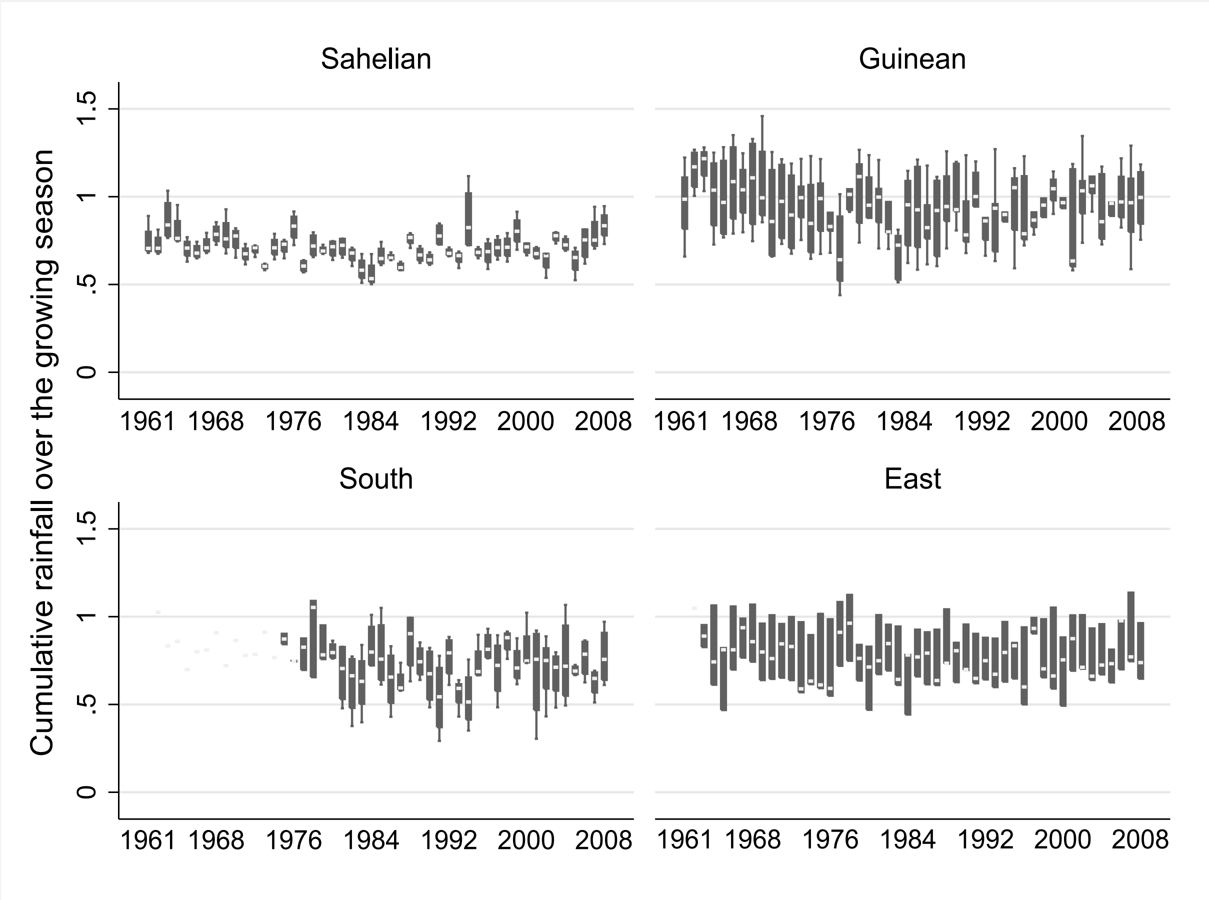

Figure 4: Box plot of cumulative rainfall over the growing season in the cultivation zone.

Table 9: Weather indices summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Whole sample					
Cumulative rainfall (thousands of mm.)	0.811	0.197	0.292	1.459	694
Season length (months)	5.356	1.64	2	10	694
Sahelian					
Cumulative rainfall	0.711	0.092	0.501	1.117	189
Season length	4.349	0.521	4	6	189
Guinean					
Cumulative rainfall	0.954	0.217	0.439	1.459	228
Season length	5.575	1.33	2	8	228
East					
Cumulative rainfall	0.791	0.16	0.442	1.137	136
Season length	7.5	1.669	5	10	136
South					
Cumulative rainfall	0.735	0.161	0.292	1.09	141
Season length	4.284	0.565	3	5	141