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Heterogeneous Welfare Effect of Cotton Pricing on Households in Benin

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***Abstract*:** Since 2004–2005 the cotton sector in Benin has been experiencing major problems that have caused a decline in production. To help the sector recover, the government intensified its intervention in the form of prices support. This study assesses the impacts of sharp increases in producer prices during the years 2009–2012 on cotton production and the distributional impacts on welfare. Using a partial adjustment model of supply response, we estimate that cotton supply elasticity ranges between 1.3 and 2.6, suggesting that cotton production responds strongly to price incentives. Next, we use concepts of compensating variation and net benefit ratio measures to analyse the welfare implications. We find that an increase in price from 190 FCFA per kg in 2009 to 250 FCFA per kg in 2012 led to a 9.8 percent increase in producers' welfare. Non-parametric regressions showed that the increase in cotton prices likely benefited all households across the entire income distribution. However, the gains are larger for rich farmers in the northern regions where cotton is predominant.

1. Introduction

Cotton is a major cash crop in Benin, where it has grown in importance consistently since the 1980s (Ahohounkpanzon and Allou, 2010). In 2009, about 20 percent of agricultural land harvested was under cotton production, which contributed an estimated 10–15 percent to the country's gross domestic product, 70–80 percent to agricultural exports and generated up to 35 percent of fiscal income (Gergely, 2009; Goura *et al.*, 2013). During the same year, the cotton sector was also a major source of livelihood for more than 237,500 households — about 35 percent of farm households — are directly involved in the production of cotton and over 2.5 million people — about 31 percent of the total population — depend on cotton revenue. Cotton is also a major driver of the industrial sector in Benin.

Given the importance of cotton in the Benin, a healthy and strong cotton sector is important for the government and the country. However, starting in 2004–2005, there has been a sharp decline in cotton production in Benin with widespread consequences for the economy. Cotton seed production reached a peak of 427,000 tons in 2004–2005, with about 313,000 hectares (ha) of cultivated land. But, in subsequent years, the amount of land planted consistently dropped, down to 145,704 ha by 2009–10, a 54 percent decrease in just six years.

The decline of cotton in Benin is the combined results of several factors. The main and oft-cited factor is a downward trend in world prices since the mid 1990s. In 1996, the international price of cotton was about US$0.77/kg; by 2005, it had fallen by 28 percent, to US$0.55/kg.[1] The world price continued to be consistently low until 2009 before soaring to US$0.92/kg in 2010–12. Over this period, the decline in price was aggravated by the degradation in the exchange rate of the franc CFA (FCFA) against the US dollar (Adom *et al.*, 2012). This decline in world prices was eventually transmitted to domestic cotton prices in Benin.

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Among the domestic factors explaining the plunge in cotton production, low producer prices received by farmers are often mentioned (Gergely, 2009). From 1992 to 1999, the farm-gate price of cotton increased from 95 FCFA/kg to 225 FCFA/kg. After reaching this peak, the price continued falling during the 2000s down to 170 FCFA/kg in 2006–2007 and 2007–2008. Conversely, fertilizer prices continuously increased from 190 FCFA/kg to 235 FCFA/kg between 2000 and 2009, and insecticide prices remained roughly stable at 4,200 FCFA/L. Consequently, production costs have often outpaced revenue. Payments are also considerably delayed and most farmers reported having received complete payment only three or more months after the sale (COMPACI, 2010). The decline of cotton has even accelerated as a result of the increasing urbanization and the rising prices of food. In short, the profitability and the attractiveness of cotton have been declining.

Because a large number of farmers depend on cotton production, and there is widespread and persistent poverty (Alia *et al.*, 2016), a continued decline of the cotton sector has important consequences on welfare and on the entire economy (Nkurunziza *et al.*, 2017). It is in this context that the government aggressively tried to support producers by raising the producer price from 190 FCFA/kg in 2009 to 200 FCFA/kg in 2010–11, 250 FCFA/kg in 2011–12, and 260 FCFA/kg in 2012–13. The government also provided various inputs subsidies estimated at 48 billion FCFA over 2001–2009 (Ahohounkpanzon and Allou, 2010).

Various questions could be examined with regard to these pricing policies. Do cotton producers respond to price incentives? Are they significantly better off after these successive increases in price? How are any potential effects distributed across producers? This paper aims at addressing these questions. We first analyse the responsiveness of cotton production to price increases. For this purpose, we estimate cotton supply elasticity and simulate the change in the cotton area induced by the price changes. We then examine the distributional effects of the policies across regions and types of farmers.

The remainder of the paper is organized as follows. Section 2 describes the institutional setting of the cotton sector in Benin, with a focus on the pricing mechanism. Section 3 reviews the related literature. Section 4 outlines the methodology and describes the data. Section 5 discusses the results and Section 6 summarizes the findings and their implications.

2. Background

Since independence, and up until the early 1990s, the Benin cotton sector was managed by parastatal agencies and the producer price was guaranteed and fixed by the government (Depetris Chauvin and Porto, 2012). The price was relatively stable over time at around 100 FCFA/kg. Prices were stabilized by a fund that acted as an insurance mechanism and sheltered farmers from swings in international prices (Badiane *et al.*, 2002).

However, this organization of the cotton sector were criticized for its inefficiency. Under pressure from both producers and development partners, the government initiated reforms in the mid 1990s (Coulter and McKenzie, 2003; Delpeuch and Vandeplas, 2013). It started with a gradual withdrawal of the government and the emergence of new entities that took on management and responsibility for various aspects (Baffes, 2007). Under the reform, a different pricing mechanism was established. The principle is extensively described in Ahohounkpanzon and Allou (2010), and only a brief summary is provided here.

In April/May, before sowing, a price is announced supposedly taking into account the costs of producers and ginners and their respective margins, following the formula:

$$P_g = [(L_c + (F * P_f) + (I * P_i)) * (1 + M_G)]/y_s \quad (1)$$

where P_g denotes the guaranteed farmgate price, L_c is the labour cost set at 129,400 FCFA/ha, F is fertilizer use set at 179.5 kg/ha, P_f is the fertilizer unit price, I is insecticide use set at 4 L/ha, P_i is the insecticide unit price, M_G is the guaranteed margins for producers set at 15 percent, and y_s is the average yield set at 1,200 kg/ha.

Later in October, the final price P_a is fixed by adjusting to the world price as follows:

$$P_a = (P_W - 45) * y_L * 72\% * (1 - 15\%) \quad (2)$$

P_W is the world price for cotton lint; 45 FCFA/kg is an adjustment to account for the cost of insurance and freight; y_L is the transformation rate from cotton seed to cotton lint; 72 percent is the share of cotton seed in cotton lint value; and 15 percent is the ginners' margin. If the final price is above the guaranteed price, part of the difference is supposed to be accumulated in a reserve fund. If it is below, the reserve fund pays the difference in the form of a subsidy.

The application of the mechanism encountered many difficulties. The actors usually did not agree on the value of the different parameters. This generally led to an unclear application of the mechanism and created conflicts between the different actors, causing the government to frequently interfere to unilaterally fix the price. In most cases, the government has the final word on the price, leading often to fixing a 'political price', especially in election years (Baffes, 2007; Gergely, 2009).

3. Related Literature

The analysis of the agricultural supply response to economic incentives dates to the early 1950s (Nerlove, 1958; Sadoulet and De Janvry, 1995; Traoré, 2013). Most studies conclude that farmers in developing countries respond weakly to price incentives (Askari and Cunnings, 1976; Ogbu and Gbetibouo, 1990; Thiele, 2003). However, results from previous studies have been flawed by several conceptual and econometric challenges. The first problem is the empirical formulation including the identification of correct prices and control variables to include in the analysis and the functional relation between prices and production. The second challenge is the availability of reliable data and the choice of a suitable estimation method. In the case of an export-oriented crop such as cotton, there is a trade-off between focusing on the world price effect and its impact on the domestic producer price, and focusing on domestic prices.

Previous studies that have estimated cotton supply response to world prices find mixed results. Gilson *et al.* (2004) estimated the elasticity of cotton for 26 countries for 1969–2001 controlling for the price of competing crops. The short-run elasticity estimated for Benin is about 0.25, among the lowest in the sample of countries included, and is statistically insignificant. The elasticity for other African countries ranges from 0.28 for Tanzania to 0.57 for Côte d'Ivoire. Shepherd (2006), using a structural time series approach and aggregated data for 1961–2004, found an elasticity of 0.01, which was not significant. Hugon (2005) also found a low but statistically significant elasticity of 0.13 for 1971–97. However, Araujo *et al.* (2006) estimated a higher elasticity in the range of 0.75–0.88.

Another set of studies have instead used national prices to estimate cotton supply elasticities. Douya (2008) and Vitale *et al.* (2009) estimate farmer's response to cotton price using farm-level data in Cameron and Mali respectively. Theriault *et al.* (2013) and Yu *et al.* (2011) use instead regional data for Mali and China respectively. Mittal and Reimer (2008) use national price in India. Bautista and Gehlhar (1996) and Danielson (2002) also use national price in Egypt and Tanzania respectively. Overall, the elasticity of supply response found using domestic prices are generally higher than the one found using world prices.

Both the use of world price of cotton lint and aggregated data for the estimation of supply response are somewhat problematic. Because of the price stabilization policy implemented for several years, changes in the world cotton price are not perfectly transmitted to domestic prices in Benin. Also, the theoretical specification underlining the estimation is at the farm level. In the absence of farm-level panel data, our approach is to take advantage of the availability of panel data on production and domestic prices at the second administrative subdivision level (commune) for a relatively long period of time.

The second objective of our paper is to assess the welfare effects of the price increases which have also been examined in the literature. Minot and Daniels (2001), using household survey data in 1998, find that a 40 percent decrease in the producer price reduces farmer per capita consumption by 7 percent in the short run and by 5–6 percent in the long run. Their findings are corroborated by Ahoyo (2004) who finds that a decrease of 10 percent in the cotton price will reduce household per capita consumption by 5 percent. Our paper extends these previous findings using the most recent data and with a focus on the recent policy experiment of price increases initiated by the government. We also add to the literature distributional results on the impacts of cotton price changes on household welfare with disaggregation across Beninese regions.

4. Methodology

4.1 Estimation of Cotton Supply Response

To estimate the supply response of cotton to price changes, we consider a Nerlovian partial adjustment model (Nerlove, 1958; Sadoulet and de Janvry, 1995). In this framework, supply response is estimated using the anticipated price of cotton and other competitive crops. The popularity of this model resides in its simplicity and straightforward estimation.

To formally discuss the model, let us consider a representative farmer in a commune i making an optimal production decision at the beginning of the agricultural season t. The farmer chooses the optimal amount of land to allocate to each of the alternative crops to maximize his/her 'profit or expected'. This maximization problem yields the following reduced form cotton supply function:

$$A_{it} = \alpha + \beta A_{it-1} + \theta_C P_{it}^{C,e} + \varphi \bar{P}_{it}^{e} + \gamma Z_{it} + u_{it}, \tag{3}$$

where for the farmer i, A_{it} is the total land devoted to cotton in year t, $P_{it}^{C,e}$ is the expected price of cotton, which in our case, is the same for all farmers; $\bar{P}_{it}^{e}$ represents the price index[2] for alternative crops to cotton constructed as a weighted average of individual crop prices with the weights being total production; Z_{it} is a set of exogenous supply shifters, and u_{it} represents an error term.

In Equation (3), the (future) prices of cotton and other crops are expected to prevail after production decisions have been made and harvest has occurred and might be unknown to farmers. Thus, farmers have to form some beliefs about the value of expected prices. Various approaches have been used to circumvent this challenge. Gardner (1976) suggests the use of planting-time price if available, arguing that farmers' rational expectation of post-harvest price is equal to pre-planting price. The cotton pricing system described previously is such that, before planting, farmers know with certainty the price that will prevail at harvest. Thus, following Gardner (1976), we can reasonably assume that $P_{it}^{C,e} = P_{it}^{C}$ and that there is no need to have a model of price expectation formation for the cotton price. On the other hand, the prices of the alternative crops are not set by the government — they are highly volatile throughout the year and hardly predictable by farmers. For simplicity purposes, we assume that farmers are rational and will use the price observed the previous year as a rational expectation for the price next year. This assumption means that we set $\bar{P}_{it}^{e} = \bar{P}_{it-1}$ for alternative crops to cotton. Since farmers are fully aware that the price of alternative crops might fluctuate, we also control for price volatility by including in the model the within year standard deviation $\sigma(\bar{P}_{it-1})$ of the price of these alternative crops. Finally, the equation we estimate is:

$$A_{it} = \alpha + \beta A_{it-1} + \theta_C P_{it}^{C} + \varphi \bar{P}_{it-1} + \delta\sigma(\bar{P}_{it-1}) + \gamma \mathbf{Z}_{it} + u_{it} \tag{4}$$

The vector **Z** is a vector of exogenous supply shifters and includes a time variable to account for effects that may result from technology changes in cotton production over time, rainfall capturing exogenous climatic shocks and the prices of inputs (fertilizers and insecticide). In this final model, θ_c represents the short-run price elasticity of cotton and is expected to be positive. The magnitude of θ_c characterizes the strength of the response of cotton acreage to price increases. The cross-price elasticity φ captures the effect of changes in the price of alternative crops on cotton acreage.

The underlying assumption for the identification of cotton supply elasticity is the exogeneity of future or lagged prices. This exogeneity has been implicit in the earlier analysis of cotton supply. However, the plausibility of this exogeneity assumption is questioned by recent studies on the supply response of agricultural products. In fact, unobserved supply shifters could also affect future prices through anticipated demand and supply (Choi and Helmberger, 1993). This endogeneity problem will bias ordinary least square estimate of elasticities.

To address endogeneity issues, Roberts and Schlenker (2013) suggest the use of an instrument variable approach. They argue that a good instrument should introduce a shift in price that is unrelated to an unobservable shift in the supply curve. A good candidate is a weather-based instrument as such instruments are typically outside of the decision set of farmers since they are realizations of nature. Roberts and Schlenker (2013) exploit this idea to construct an instrument using a yield shock measured as the deviation from the yield trend conditional to rainfall. We follow their approach to construct similar instruments prices. We use the past yield shocks measured as the deviation from the yield trend controlling for rainfall which does not directly affect cotton demand. We can argue that this variable should be uncorrelated to unobservable that affect cotton acreage decision, but somewhat correlated with prices. We use in the empirical analysis various statistical tests to assess the validity of the instrument. We should, however, mention the caveat that the instrument might be correlated with anticipated yield, and in this case, farmers might adjust their land area according to their expectation. If this is the case, the validity of the instrument will be questioned. In our simulation, we report a sensitivity analysis by varying the value of the supply elasticity and the results are not substantially affected.

4.2 Estimation of the Welfare Effect on Cotton Producers

To examine the welfare effect of cotton pricing, we follow the framework developed by Benjamin and Deaton (1993) and consider the following simple equation describing producer income formation:

$$Y = \pi^{C}(p^{c}, C^{c}) + \sum\nolimits_{j \neq C}^{J} \pi^{j}(p^{j}, C^{j}) + L + \mu \tag{5}$$

where Y represents total household income from all possible sources; $\pi^C(p^c, C^c)$ is the income from cotton production, with p^c representing the cotton price and C^c being the total cost of cotton production; the upper index j indicates the same variables for all other alternative crops to cotton; L is total labour income, and μ is the income from all other sources. In developing countries, income is not a good measure of welfare, as it is often mismeasured and does not reflect actual consumption. Thus, as suggested by Benjamin and Deaton (1993), we use expenditure as the measure of welfare.

Since cotton is not a food crop, the channel through which a change in cotton prices can directly affect cotton producers' welfare or expenditure is through its effect on cotton revenue. Therefore, we consider the estimation of the response of consumption to cotton production. Benjamin and Deaton (1993) derive a good approximation of this first-order effect as follows:

$$\mathrm{dln}E = \frac{Q^c \mathrm{d}p^c}{E} = \frac{Q^c p^c}{\mathrm{i}} \mathrm{dln}p^c \tag{6}$$

where Q^c is total production and E is total consumption expenditure. Benjamin and Deaton (1993) term the elasticity of income with respect to prices 'benefit ratio'. This also represents the 'revenue ratio' of cotton. This ratio can be regressed against per capita expenditure using a non-parametric regression to estimate the distributional effects of the price changes.

Equation (6) is valid under infinitesimal change (Benjamin and Deaton, 1993). For a large price change, as in our case, the approximation error is larger, and it is important to account for the supply response. Since prices are announced around April before planting, and are guaranteed, it is likely that farmers make some adjustment decisions in their production. In the short run, if farmers are not land-constrained, they can grow more cotton with marginal land available. Thus, we also simulate the welfare effect of a change in the cotton price taking into account the farmer supply response using the second-order welfare approximation described by the following formula:

$$\Delta E \approx \frac{Q^c p^c}{E} \mathrm{dln}p^c + \frac{1}{2} \theta_C \frac{Q^c p^c}{E} [\mathrm{dln}p^c]^2 \tag{7}$$

In this equation, the left-hand side ΔE is the net change in total expenditure. The first term of Equation (7) represents the first-order effect of the cotton price change. The second term adjusts the first-order effect by taking into account the farmer supply response measured by the supply elasticity of cotton θ_C.

4.3 Data Sources and Descriptive Analysis

Price and Production Data

The data on annual production and area for the main crops in all 77 communes from 1995 to 2011 come from the Beninese National Statistical database. Cotton is not produced in several communes in Benin, principally in the southern part of the country, because of unsuitable agronomic conditions. As a consequence, many communes have been excluded because they have zero cotton production for the entire period. In fact, it is unlikely in these communes that farmers would respond to the cotton price incentive. The final sample used in the estimation of supply elasticity contains 42 communes.

Seven alternative crops to cotton were identified in Benin based on data reported by farmers. These crops are maize, millet, sorghum and related crops, rice, yam, cassava and other tubers, beans and related crops, and peanuts and related crops. The choice of these crops is mainly motivated by the fact that they are typically cultivated in the same agroecosystem as cotton. Table 1 presents some basic descriptive statistics. Cotton is the third largest crop nationally in terms of harvested area, just behind maize and yam.

The price data of various agricultural products in different local and regional markets were obtained from the Ministry of Agriculture, Livestock, and Fisheries of Benin. The initial dataset contains monthly prices for 46 agricultural products from January 1995 to January 2013 collected from 79 markets. All prices were deflated using the consumer price index from the World Development Indicators database (World Bank, 2012). While the cotton price have no month-to-month variation, prices of other crops have relatively high volatilities over time and space. Thus, risk-averse farmers could still have strong preferences for cotton farming despite its lower price.

Table 1: Average area (000s), production (000s), and output price of various crops

	Cotton	Maize	Millet and others	Rice	Yam/cassava and other	Beans and other	Peanut and other
Harvested area (ha)	265.8	369.3	193.0	27.5	269.0	128.9	114.4
Production (tons)	274.9	385.6	170.5	57.7	1800.0	79.4	96.5
Producer price (FCFA/kg)	186	122	159	303	155	270	352
Within year price variability (FCFA/kg)	0	25	28	25	41	48	51

Source: Authors' calculations based on data from the Ministry of Agriculture, Livestock and Fisheries.

Household Data

Our household data come from a survey conducted in 2009–10 by CEBEDES and funded by SNV (CEBEDES and SNV, 2010). The survey was designed to collect baseline data of the SNV-funded Program for Capacity Building of Cotton Producer Organizations (PROCOTON). It covers all cotton-producing areas, both those where PROCOTON has its activities and those where it does not. The survey collects data on production, area, and revenue from cotton production, consumption, and demographic variables.

The survey adopted a stratified three-stage sampling method. The strata were determined by agro-ecological zones of the country. In the first stage, one or two communes were randomly selected within each stratum, depending on the size of the zone in terms of the number of communes and farmers. Up to 14 communes were selected. In the second stage, one village was selected per commune. In the third stage, 30 agricultural households were randomly selected in each commune for a total of 420 farming households. We grouped all agro-ecological zones in the north under the denomination 'Zone-North', and the two agro-ecological zones of the south under 'Zone-South'.

Of the 420 households selected, 180 grew cotton during the agricultural year. Household production, harvested area for each crop, and total consumption were obtained by aggregating over all members. Household size was converted into an adult equivalent scale to compute per capita consumption. Table 2 presents descriptive statistics on the main variables used in the analysis. Average total expenditure by household is estimated at 1,096,566 FCFA (US$2,436.8) per year for a per capita consumption level of 164,862 FCFA (US$366.4) per year. Most of the demographic variables are comparable for both cotton farmers and non-cotton farmers. However, total expenditure and per capita expenditure are slightly higher for cotton farmers than for non-cotton farmers, implying that the former seem to be better off.

5. Results

5.1 Cotton Supply Response

We estimated the partial adjustment models as specified in Equation (4) using commune-level data from 1995 to 2011. Table 3 summarizes the findings on the supply response. We provide results for alternative estimators including the OLS, the fixed effect,

Table 2: Descriptive statistics

Variable	All farmers	Cotton farmers	Non-cotton farmers
Household size	6.5	6.9	6.1
Percentage of head of household with primary education	25	26	25
Average age of head of household	48.4	48.0	48.8
Percentage of female-headed household	4	4	4
Average household expenditure (000s FCFA)	1,096.6	1,213.1	995.9
Average per capita expenditure (000s FCFA)	164.9	171.5	159.1
Average cotton area (ha)		3.0	
Average revenue from cotton (000s FCFA)		790.5	

Source: Authors' calculations.

Table 3: Supply elasticity of cotton in Benin using various methods, 1995–2011

Dependent variable	OLS	Panel FE	GMM DYN	2SLS
Lag cotton area	0.844***	0.572***	0.875***	0.613***
	(0.03)	(0.03)	(0.05)	(0.55)
Cotton price	1.310***	1.377***	1.457***	2.635***
	(0.44)	(0.48)	(0.18)	(0.06)
Lag index price of alternative crops	–0.284*	–0.250	–0.131	–0.395**
	(0.17)	(0.16)	(0.10)	(0.19)
Volatility index price of alternative crops	–0.001	–0.001	–0.004***	–0.002
	(0.00)	(0.00)	(0.00)	(0.00)
Log of rainfall	0.427*	0.587**	0.597***	0.505**
	(0.25)	(0.27)	(0.15)	(0.24)
Lag log of fertilizer	3.900***	3.280***	4.148***	5.593***
	(1.15)	(1.12)	(0.34)	(1.20)
Lag log of herbicide	–0.734**	–0.767	–0.715***	–0.441*
	(0.36)	(0.54)	(0.09)	(0.25)
Time trend	–0.058*	0.029	–0.057**	0.076**
	(0.04)	(0.04)	(0.03)	(0.03)
Time trends squared	–0.001	–0.007***	–0.001	–0.009***
	(0.00)	(0.00)	(0.00)	(0.00)
R-squared	0.748	0.599		0.613
AR(2)/Pr > *z*			1.2/0.23	
Override test/ Pr > chi^2			34.69/1.00	
Shea Partial *R*2 (first stage)				0.47
First stage *F*-stat				1715.56***
Hansen *J* statistic/*P*-value				8.02/0.05
Endogeneity test				10.3***
Number of observations/communes	672/ 42	672/ 42	672/ 42	672/ 42

Note: Commune level clustered standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. OLS = ordinary least square; GMM = generalized method of moments; DYN = dynamic; 2SLS = two-stage least squares. In the 2SLS, the excluded instruments are current cotton yield shock, lag cotton yield shock, lag yield shock for alternative crops, time trend. Yield shock is obtained as the jackknifed residual of the regression of yield over a quadratic time trend conditional on rainfall.

the Arellano-Bond estimators, and the 2SLS. Qualitatively, the results of these estimators are similar except the 2SLS which is almost double the other estimates. For the reasons argued earlier, the IV estimate is our preferred estimation. We report various statistics to evaluate the validity of the instrument. The first stage partial *R*-squared and *F*-statistics help us test the hypothesis of weak instruments. We also test the endogeneity of price. All these tests lead to conclude that our yield shock is a good and valid instrument.

We find a positive and significant response of cotton area using the standard Nerlovian model. The point estimate of the short-run elasticity, when we correct for potential endogeneity of the cotton price, is relatively high (2.6). This suggests that government policy to support the producer price could potentially lead to an increase in cotton production, both in the short and long run.

However, the result is in line with some of the literature but substantially different from a number of studies. In a survey of cotton responses in selected African countries, Askari and Cunnings (1976) found that short-run elasticity of cotton is low. Most studies they surveyed use the standard Nerlovian response model. Our results using this type of model are consistent with this finding. Minot and Daniels (2001) also argued that a possible range for cotton supply elasticity for Benin was between 0.5 and 1.5. Our study has the advantage of addressing price endogeneity issues inherent to most supply-model estimates using the Nerlove model. Based on the results of our instrumental variable method, we could argue for cotton supply elasticity in Benin of 2.6. In the long run, price incentives induce farmers to further increase the cotton supply.

However, the magnitude of the response should be taken with caution. This may be partially due to at least two reasons. The first reason is the use of commune-level data instead of individual farmer data, which were, unfortunately, unavailable. In fact,

if many new farmers or returning cotton farmers undertake cotton production as a result of the price increase, it is possible to observe a large supply response at the commune level, while at the individual farmer level the average response is relatively small. A second reason that might explain why our point estimate of the elasticity is high is the use of the instrumental variable approach. As we argue in the methodology section, the standard Nerlovian approach typically yields low elasticity due to the downward bias caused by the endogeneity of prices. The results of this approach yield an elasticity of 1.3, which is in the range of 0.5–1.5 in Minot and Daniels (2001).

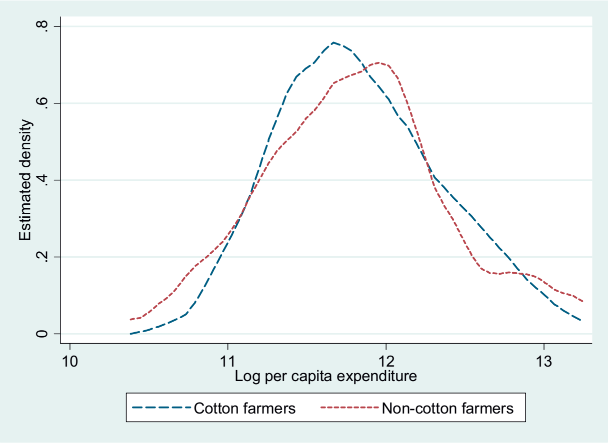
A number of other important results could be highlighted. The coefficient of the lagged dependent variable is positive, statistically significant, and less than the unit for most of the estimations. This result is consistent with the partial adjustment model adopted. We find that the competition between cotton and alternative crops is relatively weak. Although the coefficients of the expected price indices of alternative crops in the cotton supply regression are negative, they are not significant in all specifications. However, we find that as the volatility of the alternative crops increases, the area planted with cotton tends to expand. This finding may also be interpreted as evidence of risk aversion among cotton farmers. Cotton production offers farmers more stable revenue and they seem to prefer that when growing the alternative crops becomes riskier. Most of the other control variables in the regressions have their expected signs.

5.2 Effect of a Cotton Price Change on Cotton Farmers

Benefit Ratio of Cotton Production and Household Welfare

Before analysis of the effect of cotton price change of household welfare, it is important to explore the distribution of household expenditure to get some insights in how the pricing policies might impact households. Figure 1 presents the kernel density of the logarithm of per capita expenditure for cotton producers and non-cotton producers. It shows important overlaps between the distributions of per capita expenditure for cotton farmers and non-cotton farmers. The mode for non-cotton farmers is slightly higher, suggesting that non-cotton farmers might be slightly better off than cotton farmers. However, that comparison depends largely on where in the income distribution households are located. The figure also reveals that the density of cotton farmers is more important in the middle of the per capita expenditure distribution, mostly for log of expenditure between 11 and 12, corresponding to per capita expenditure between 59,874.1 FCFA and 162,754.8 FCFA. It can be argued that most cotton farmers are concentrated below and just above the rural poverty line of 109,400 FCFA per capita per year. The figure also shows that the distribution of expenditure of cotton farmers is slightly at the right of the distribution of expenditure for non-cotton farmers. Thus, an increase in the producer price of cotton will likely shift cotton farmers' expenditure distribution further to the right making them relatively better off than other farmers.

Figure 1: Kernel density of the logarithm of per capita expenditure [Color figure can be viewed at wileyonlinelibrary.com]



Source: Authors' calculations.

Table 4: Summary statistics on the net revenue ratio of cotton production (per cent)

	National	North	South
All farmers	16.1	21.1	5.9
	(27.1)	(29.7)	(16.6)
Cotton farmers	32.9	39.8	14.5
	(30.8)	(30.3)	(23.6)

Note: Average net revenue ratio and its standard deviation in parentheses.

The explanatory analysis above provides some intuitions on the potential effect of a price increase on the welfare. We now turn to the quantification of these effects. We first compute the benefit ratio of cotton production as the cotton income share, which can be used to analyse the effects of a small increase in the cotton price. Next, we simulate the welfare effect of a large price change of the magnitude that has occurred recently. Summary statistics of the benefit ratio are presented in Table 4.

Under the baseline scenario of a cotton price equal to 190 FCFA/kg, the average net revenue ratio of cotton across all cotton farmers is 32.9 percent. The ratios are also much higher in the north than in the south. The analysis of the average revenue ratios suggests that average farmers will benefit from a price increase. All else being equal, a 1 percent increase in the cotton price will raise total expenditure by 0.33 percent for an average cotton-producing household. This increase in welfare for cotton producers will translate into a 0.16 percent increase in total expenditure for an average household in Benin.

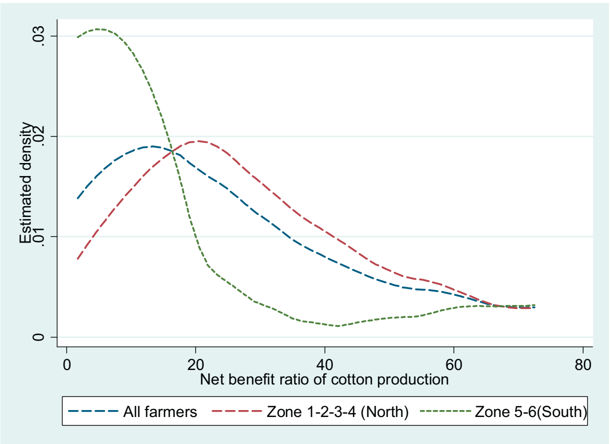
To evaluate potential heterogeneity across farmers, Figure 2 plots the density of the revenue ratio. The distribution of the revenue ratio is right skewed, more importantly in the southern regions and mostly concentrated below 20 percent, suggesting that a high proportion of farmers derive less than 20 percent of their income from cotton production.

Figure 3 regresses the benefit ratio on the log of per capita expenditure. The regressions show that the cotton price increase will benefit all farmers across the entire distribution of per capita expenditure. However, when looking at the analysis by region, it appears that poor farmers in the south benefit much more than their richer counterparts in their region. The regression lines are almost flat in the north, suggesting that the producer price increase might contribute to an almost similar compensating variation in the north.

Simulation of the Ratio of Cotton Production and Household Welfare

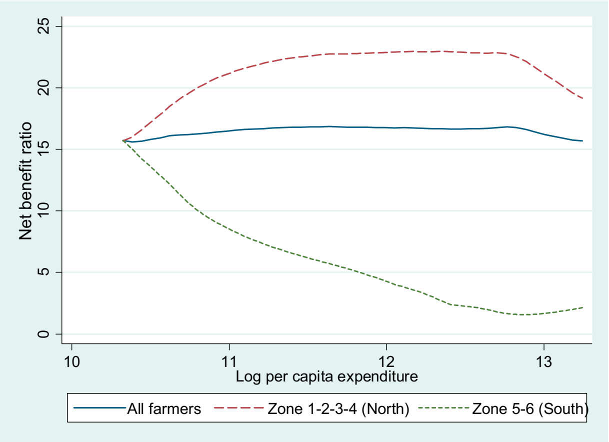
The simulation of the welfare effect of cotton price change is based on a first-order and second-order welfare change formula. The second-order effect accounts for a behavioural response using cotton supply elasticity. In our main simulation, we use the

Figure 2: Kernel density of the baseline net benefit ratio of cotton production [Color figure can be viewed at wileyonlinelibrary.com]



Source: Author's calculations.

Figure 3: Relation between the baseline net revenue ratio and per capita expenditure [Color figure can be viewed at wileyonlinelibrary.com]



Source: Author's calculations.

short-run elasticity of 2.6, consistently estimated using the 2SLS method. The different simulations considered are producer price increases from 190 FCFA/kg to 200 FCFA/kg (simulation 1), from 190 FCFA to 250 FCFA/kg (simulation 2), and the overall increase from 190 FCFA/kg to 260 FCFA/kg (simulation 3). The results are presented in Table 5.

The analysis finds a substantial welfare gain for cotton producers as a result of a farm-gate price increase. The magnitude of the welfare gain depends on the extent of the price change and the order of the welfare approximation used. The smallest price increase, from 190 FCFA to 200 FCFA (5.2 percent), would increase household welfare by 1.6 percent. For larger price changes, as in simulations 2 and 3, the welfare increases are stronger. Thus, for a price of 250 FCFA corresponding to a 31.6 percent increase, the direct welfare gain is about 9.8 percent. If farmers respond by expanding their cotton production, the welfare gains are slightly larger. The welfare effect also varies across geographical regions.

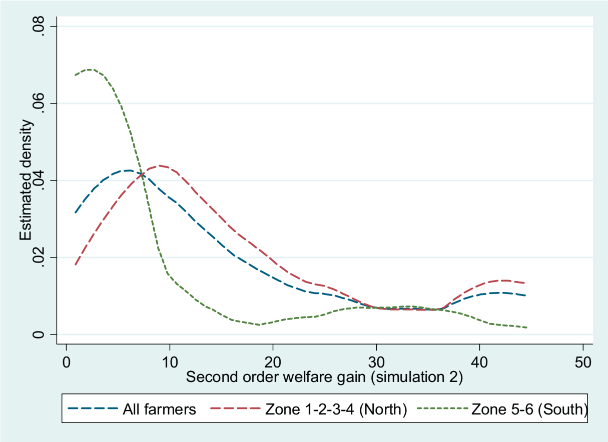
The results are qualitatively similar across simulations. In fact, the welfare gain equation is quasi-linear and the price change impact from one simulation can be easily extrapolated to larger or smaller price changes. One simulation conveys enough information on the welfare gain. We analyse the distribution of the welfare effect by plotting the kernel density function of the second-order welfare gain of simulation 2, as illustrated in Figure 4. The density function is right-skewed for all simulations, with the welfare gains concentrated between 10 and 30 percent. All the other simulations display similar patterns.

Table 5: Summary statistics on the welfare change of a cotton price increase (per cent)

	Simulation 1: 190 to 200 FCFA/kg (+5.2 per cent)	Simulation 2: 190 to 250 FCFA/kg (+31.6 per cent)	Simulation 3: 190 to 260 FCFA/kg (+36.8 per cent)
National			
First-order effect	1.6	9.8	11.4
Second-order effect	1.7	13.8	16.9
North			
First-order effect	1.9	11.3	13.2
Second-order effect	2.0	15.9	19.5
South			
First-order effect	0.7	4.3	5.0
Second-order effect	0.8	6.0	7.4

Source: Authors' calculations.

Figure 4: Kernel density of the welfare increase of a cotton price change (simulation 2) [Color figure can be viewed at wileyonlinelibrary.com]



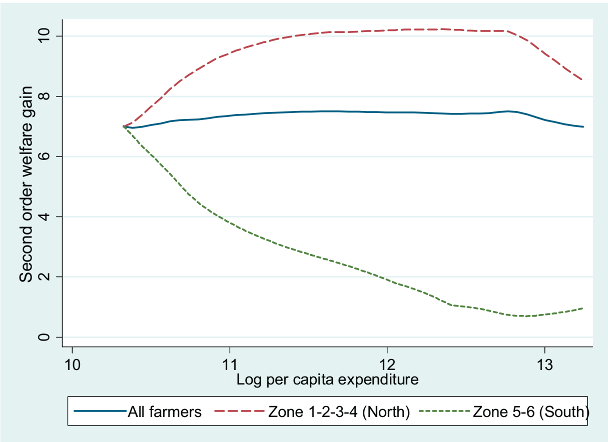
Source: Authors' calculations.

From Figure 4, it can be seen that all farmers across the entire distribution of per capita expenditure benefit equally from the price increase. To evaluation the heterogeneity in the welfare grains, Figure 5 regresses the welfare increase on the log of per capita expenditure. This result is consistent with the observation from the benefit ratio plots. However, for large price increases, as modeled in simulation 2, richer farmers seem to have a little advantage over poorer farmers, although in the south this observation is reversed.

Finally, we quantify the poverty reduction effect of the price increase. Assuming that the rural poverty line remains constant, we estimate that a 31.6 percent increase in the cotton price decreases poverty among cotton farmers by 7 percent, from 36.8 to 29.8 percent. This decrease is well captured in the shift of the entire distribution of expenditure to the right as illustrated in Figure 6.

To assess the robustness of the analysis to, we perform a sensitivity analysis by varying the estimated supply elasticity. We consider two alternatives (Table 6): a lower elasticity using the Nerlovian model $\theta_C = 1.4$ and second value even higher of 2.6 and a second much lower value of 0.5 as found by Minot and Daniels (2000).

Figure 5: Relation between the second-order welfare gain and per capita expenditure [Color figure can be viewed at wileyonlinelibrary.com]



Source: Authors' calculations.

Figure 6: Comparison of the density of per capita expenditure before and after the price change [Color figure can be viewed at wileyonlinelibrary.com]

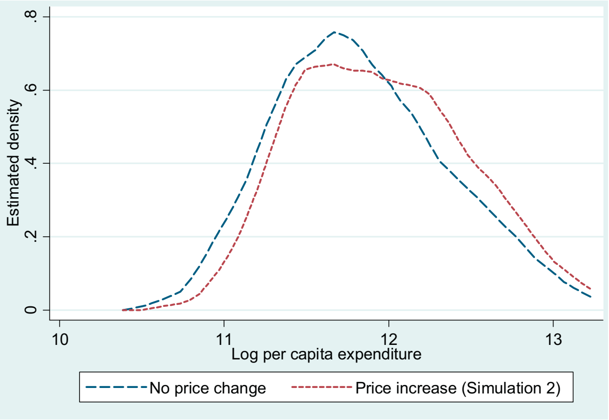


Table 6: Summary sensitivity analysis on welfare change of cotton price increase (per cent)

	Simulation 2 (baseline) 190 to 250 FCFA/kg (+31.6 per cent)	Sensitivity 2 Baseline + Elasticity = 1.4	Sensitivity 3 Baseline + Elasticity = 0.5
National			
First-order effect	9.8	9.8	9.8
Second-order effect	13.8	12.0	10.6
North			
First-order effect	11.3	11.3	11.3
Second-order effect	15.9	13.8	12.2
South			
First-order effect	4.3	4.3	4.3
Second-order effect	6.0	5.2	4.4

Source: Authors' calculations.

The pattern in the results observed in the main scenario is preserved in all scenarios. When the supply response of the cotton farmer is decrease from 2.6 to 1.4 or 0.5, the total welfare gain for a 31.6 percent cotton producer price increase is still important, but only very slightly from 13.8 percent to 12.0 percent and 10.6 percent respectively. This suggests that the results are relatively robust to the value of the supply elasticity.

6. Conclusion

This paper estimates the cotton supply response to price incentives, using panel data from cotton-producing communes, and assesses the welfare impact of cotton pricing in Benin. The paper formulated a partial adjustment model of cotton area and constructed an instrument based on yield shock to identify and consistently estimate cotton supply elasticity. We find that the cotton response to price incentives is relatively important.

The welfare analysis shows that the associated welfare gains for the price increase since 2009 are relatively important. We also find that benefits are shared by all cotton farmers, although to different degrees, across all regions and across the income distribution. The gains are higher in the major cotton-producing areas in the north than in the southern regions. While in the northern regions the welfare gain almost equally accrues to both poor and rich farmers, the gain for poor farmers is larger than that of richer farmers in the south.

The positive impact on the welfare of cotton farmers seems to support the price policy option of setting a relatively fair producer price in order to sustain the cotton sector and reduce rural poverty. The welfare gain appears as an efficient transfer from the government to cotton farmers. By setting a relatively high price for cotton producers, the government is to some extent reducing its potential revenue from cotton. However, as long as the price is kept in line with the world price, the government does not incur losses, and cotton farmers and the more than 3 million persons indirectly associated with cotton farming are better off.

The results of the supply response analysis suggest that cotton farmers respond to price incentives by expanding the area planted with cotton. The potential for such expansion exists, especially in the north where vast amounts of land are still unexploited. Suitable policies could be implemented to support the cotton area expansion, including such policies as access to credit and farming facilities (equipment, land, etc.) for start-up farmers (including unemployed persons willing to become farmers). These facilities include initial support to access seed, fertilizer, and other inputs; and farming equipment for cotton production. Initiatives and policies such as microcredit for young entrepreneurs and for business development, capacity building, and facilitating market access undertaken by the National Employment Promotion Agency and the National Microfinance Fund needs to be reinforced, efficiently conducted, and oriented towards the agricultural sector.

Notes

1. The exchange rate USD to FCFA was 511.52 in 1996 and 527.47 in 2005.
2. Alternatively we could also formulate a more general model $A_{it} = \alpha + \beta A_{it-1} + \theta_C P_{it}^{C,e} + \sum_{j=2}^{J} \theta_j P_{it}^{j,e} + \gamma Z_{it} + u_{it}$, where $P_{it}^{j,e}$ is the expected price of the alternative crop *j*. Instead, we choose to put together all the alternative crops farmers might grow as a substitute to cotton to focus the analysis on the estimation of cotton supply elasticity θ_C.

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