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# The WTO Doha Round, Cotton Sector Dynamics and Poverty Trends in Zambia<sup>1</sup>

by

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## **Abstract**

The Zambian cotton sector has gone through significant reforms during the 1990s. After a long period of parastatal control, a process of liberalization in cotton production and marketing began in 1994. These reforms were expected to benefit agricultural farmers. In Zambia, these are rural, often vulnerable, smallholders. This paper investigates the connection between the dynamics of the cotton sector and the dynamics of poverty and evaluates to what extent cotton can work as a vehicle for poverty alleviation. We find that cotton can indeed act as an effective mechanism for increased household welfare. We find income gains associated with cotton production as well as positive impacts on the long-run nutritional status of Zambian children. The impacts, however, are relatively small.

## Introduction

The Zambian cotton sector has been profoundly reformed during the last ten years. Traditionally, cotton production was controlled by the government through public firms and parastatal organizations. Until 1994, Lintco (Lint Company of Zambia) sold inputs on loan and purchased cotton seeds from farmers. The reforms comprised a broad liberalization of the sector that included the privatization of Lintco and the encouragement of market entry. The dynamics of the sector include an initial phase of regional private monopsonies, and a later phase of more active competition. At present, the market is relatively unregulated and several firms seem to freely compete (but may collude) for locally produced cotton seeds.

Poverty in Zambia is a deep phenomenon, particularly in rural areas. In 1998, for example, the head count was 82.1 percent. Moreover, poverty in some regions exceeded 90 percent. Cotton is one of the key agricultural activities in rural Zambia. In cotton growing provinces, a large share of the cash income of rural farmers come from the sales of cotton seeds.

This paper studies the dynamics of cotton production and marketing and the links with rural poverty. It has long been claimed that cash crops can work as an effective vehicle for poverty alleviation in rural areas. Hence, we set out to explore whether cotton can actually be trusted to achieve significant reductions in poverty in Zambia.

We start by reviewing the reforms in the cotton sector. Since cotton can only be produced in selected regions in Zambia, we examine the trends in poverty and cotton income in different provinces. To investigate the role of cotton as a source of household income, we perform two different empirical exercises. First, we look at the evolution of the share of income generated by cotton and we simulate the poverty impacts brought about by an increase in cotton prices and an

expansion of the sector. Second, we compare different outcomes between households in cotton and households in subsistence. We look at income differentials, anthropometric measures and educational outcomes.

Our findings are mixed. On the one hand, we find that cotton production is associated with higher household income, lower poverty, and higher welfare. This result has two components. First, higher cotton prices would benefit rural farmers directly. Second, cotton farmers enjoy income gains and long-run nutritional gains as compared to subsistence farmers. On the other hand, we find that the estimated magnitudes are not as large as expected. Very large price changes of cotton seeds or very large supply responses would be needed to estimate empirically meaningful reductions in poverty rates. We conclude that international trade in cotton is indeed a promising activity for rural farmers, but that there is a long way to go to achieve the full benefits from increased market access and higher prices. Reforms in the provision of infrastructure, access to credit, extension services, and social services are essential complementary policies to market access and liberalization of agricultural markets in the developed world.

The paper is organized as follows. In Section 2, we review the main reforms in cotton markets, we discuss the characteristics of world cotton markets, and we provide a poverty profile of Zambian households. In section 3, we look at cotton as a source of cash income, and we simulate the impacts of market access and higher international prices. In section 4, we estimate income differential gains in cotton over subsistence agriculture. We study non-monetary outcomes as well, like educational and nutritional status. In section 5, we review our main results and we summarize our conclusions.

# 1. Cotton Reforms and Poverty Trends in Zambia

Zambia is a landlocked country located in southern central Africa. Clockwise, neighbors are Congo, Tanzania, Malawi, Mozambique, Zimbabwe, Botswana, Namibia, and Angola.<sup>4</sup> In 2000, the total population was 10.7 million inhabitants. With a per capita GDP of only 302 US dollars, Zambia is one of the poorest countries in the world and is considered a least developed country.

The Republic of Zambia achieved Independence in 1964. A key characteristic of the country is its abundance in natural resources, particularly mineral deposits (like copper) and land. Due to high copper prices, the new Republic did quite well in the initial stages of development. Poverty and inequality, however, were widespread and this raised concerns among the people and the policymakers. Soon, the government began to adopt interventionist policies, with a much larger participation of the state in national development. Interventions included import substitution, price controls of all major agricultural products (like maize), nationalization of manufacturing, agricultural marketing and mining.

In the 1970s and 1980s, the decline in copper prices and the negative external conditions led to stagnation and high levels of external debt. A crisis emerged and a structural adjustment program was implemented between 1983 and 1985. Riots in 1986 forced the government to later abandon the reforms in 1987. A second IMF program failed in 1989, when the removal of controls in maize led to significant price increases.

In 1991, the Movement for Multi-Party Democracy (MMD) was elected. Faced with a sustained, severe recession and with a meager future, the new government began economy-wide

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<sup>4</sup>This section relies heavily on Balat and Porto (2004).

reforms including macroeconomic stabilization, exchange rate liberalization, fiscal restructuring, removal of maize subsidies, decontrol of agricultural prices, privatization of agricultural marketing, and trade and industrial policy. For a more detailed description of the reforms, see World Bank (1994), McCulloch et al. (2001) and Litchfield and McCulloch (2003).

## **1.1 Cotton Reforms**

The cotton sector was significantly affected by the agricultural reforms adopted by Zambia during the 1990s.<sup>5</sup> Before 1994, intervention in cotton markets was widespread and involved setting prices for sales of certified cotton seeds, pesticides, and sprayers, providing subsidized inputs to producers, facilitating access to credit, etc. From 1977 to 1994, the Lint Company of Zambia (Lintco) acted as a nexus between local Zambian producers and international markets. Lintco had a monopsony in seed cotton markets, and a monopoly in inputs sales and credit loans to farmers.

The reforms of the mid-1990s eliminated most of these interventions and markets were liberalized. Since Lintco was sold to Lonrho Cotton in 1994, a domestic monopsony developed early after liberalization. As market opportunities arose, several firms (private ginners such as Swarp Textiles and Clark Cotton) entered the Zambian cotton market. This initial phase of liberalization, however, did not succeed in introducing much competition in the sector. This is because the three major firms segmented the market geographically. In consequence, liberalization gave rise to geographical monopsonies rather than national oligopsonies.

At that moment, Lonrho and Clark Cotton developed an outgrower scheme with the Zambian farmers. This scheme allowed ginners to expand production and take advantage of economies of scale and idle capacity. In these outgrower programs, firms provided seeds and

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<sup>5</sup>For more details on cotton reforms in Zambia, see Food Security Research Project (2000) and Cotton News (2002).

inputs on loans, together with extension services to improve productivity. The value of the loan was deducted from the sales of cotton seeds to the ginners at picking time. Prices paid for the harvest supposedly depended upon international prices. Initially, repayment rates were high (around roughly 86 percent) and cotton production significantly increased.

By 1997, the expansion of the cotton production base attracted new entrants, such as Amaka Holdings and Continental Textiles. Instead of the localized monopsonies, entrants and incumbents started competing in many districts. As a result of entry, the capacity for ginning increased beyond production levels. This caused an excess demand for cotton seeds and tightened the competition among ginners for Zambian cotton. In addition, some entrants that were not using outgrower schemes started offering higher prices for cotton seeds to farmers who had already signed contracts with other firms. This caused repayment problems and increased the rate of loan defaults.

The relationship between ginners and farmers started to deteriorate. On top of all this, world prices began to decline, and farm-gate prices declined as a result. After many years of high farm-gate prices, and with limited information on world market conditions, farmers started to mistrust the ginners and suspicions of exploitation arose. In consequence, farmers felt that outgrowers contracts were being breached, and default rates increased. This led firms to increase the price of the loans charged to farmers, who, in the end, received a lower net price for their crops.

Partly as a result of this failure of the outgrower scheme, Lonrho announced its sale in 1999 and Dunavant Zambia Limited entered the market. Nowadays, the major players in cotton markets in Zambia are Dunavant (Z) Limited, Clark Cotton Limited, Amaka Holdings Limited, Continental Ginneries Limited, Zambia-China Mulungushi Textiles and Mukuba Textiles.

At present, most cotton production in Zambia is carried out under the outgrower scheme. Farmers and firms understood the importance of honoring contracts and the benefits of maintaining a good reputation. The outgrower programs were perfected and there are now two systems utilized by different firms: the Farmer Group System and the Farmer Distributor System. In the latter, firms designate one individual or farmer as the distributor and provide inputs. The distributor prepares individual contracts with the farmers. He is also in charge of assessing reasons for loan defaults, being able, in principle, of condoning default in special cases. He is in charge of renegotiating contracts in incoming seasons. In the Farmer Group System, small scale producers deal with the ginneries directly, purchasing inputs on loan and repaying at the time of harvest. Both systems seem to work well.

## **1.2 International Markets and World Prices**

The production of cotton and the international trade of cotton products are, and have traditionally been, subject to significant interventions. The distortions include taxes (either directly or indirectly through state marketing monopsonies (parastatals), border intervention (tariffs, quotas), production and export support, and input subsidies. Aksoy and Beghin (2004) summarize the markets for different commodities including cotton. They suggest that the combined support in cotton production in the major world producers (US, China, Greece, Spain, Turkey, Brazil, Mexico and Egypt) between 1997/98 and 2001/02 ranged from \$3.8 to \$5.3 billion.

We turn next to briefly review some of the interventions adopted by some of the main producers, namely the United States and the European Union. Our summary is based on Baffes (2004), who provide more details on cotton markets, policies, and prospects. In the United States, intervention in cotton production is regulated by Farm Bills, like the 1996 and 2002 bills. They

establish price and income support (usually de-couple payments based on historical areas planted), tariffs, quotas, public agricultural research, provision of infrastructure (irrigation), export subsidies, export credit, subsidized loans and insurance, etc. The 2002 Farm Bill is expected to be in place for the next six years.

The European Union intervenes in cotton production to provide support to Spanish and Greek producers. Under the Common Agricultural Policy of the European Union, support is given to cotton growers based on the difference between the market price and a guide (i.e. support) price. Advance payments are calculated on the basis of estimated cotton production. Ginners receive these payments and pass-through them to producers in the form of higher prices.

The effects of the removal of cotton distortions in world markets have been widely researched. Some of the literature is reviewed by Baffes (2004). He reports results from FAPRI (2002), which showed that under global agricultural liberalization world cotton prices would increase, on average, by 12.7 percent. Using similar methods, Sumner (2004) reports price increases following different scenarios of cotton reforms. On average, his findings indicate an expected increase of 11.58 percent in world cotton prices. These numbers are in line with those reported by Baffes (2004). Notice, however, that the latter paper focuses mostly on the impact on world prices of the elimination of US domestic support. The comparison of Baffes and Sumner results would indicate that most of the price changes that can be expected from the liberalization of world markets would be generated by US policies. This is confirmed by Hoekman, Nicita and Olarrega (2004), who report much lower cotton price changes from a Doha scenario that considers the elimination of trade barriers without changes in domestic support. It is unclear whether the reforms needed to achieve these increases in prices are reasonable or even feasible. Nevertheless, in section 3 below, we use these estimates to simulate the poverty effects on rural

Zambian farmers. But before doing that, we review the poverty trends observed in Zambia during the 1990s.

### **1.3 Poverty Trends**

In spite of the significant reforms adopted by the Zambian government and of the significant intervention in international agricultural markets, Zambia is one of the poorest countries in the world. Furthermore, poverty rates tended to increase during the 1990s.

Our description of the poverty trends is based on three household surveys, the 1991 Priority Surveys, and the 1996 and 1998 Living Conditions Monitoring Surveys.<sup>6</sup> The Priority Survey of 1991 is a Social Dimension of Adjustment (SDA) survey. It was conducted between October and November and covered a total of 9,886 households. Sample sizes were increased to 11,750 and 16,800 households in the 1996 and 1998 LCM Surveys.

Table 7.1 reports the poverty dynamics. In 1991, the poverty rate at the national level was 69.6 percent. Poverty increased in 1996, when the head count reached 80 percent, and then declined towards 1998, with a head count of 71.5 percent. In rural areas, poverty is widespread; the head count was 88.3 percent in 1991, 90.5 percent in 1996 and 82.1 percent in 1998. Urban areas fared better, with a poverty rate of 47.2 percent in 1991, 62.1 percent in 1996 and 53.4 percent in 1998. In what follows, our focus is on rural areas.

Poverty trends by provinces are reported in Table 7.2. Zambia is a large country, and provinces differ substantially in basic characteristics like land quality, distance to the capital, roads, etc. In particular, cotton, the commodity under investigation here, can be produced (due to soil characteristics) in only the Southern, the Central, and the Eastern provinces. At the national level, poverty increased from 1991 to 1996 and then declined in 1998. Poverty trends in Lusaka,

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<sup>6</sup>The Zambia Central Statistical Office, CSO, is in charge of conducting the surveys. The data from the 2001 LCMS was under preparation when this paper was written.

the Copperbelt, and the North-Western province are similar to those at the national level. In the Central province, poverty first declined in 1996 and then increased in 1998. In the remaining provinces, particularly in the Eastern and Southern provinces, poverty has declined throughout the whole periods.

## **2. Cotton Income and Higher Export Prices**

In this section, we investigate the potential effects of higher cotton prices on household income in rural Zambia. As argued by Deaton (1989, 1997) and others, the short-run effects of price changes can be assessed by looking at income shares. In Table 7.3, we report the average income shares for different sources of income. At the national level, the main sources of income are income from home consumption (42.5 percent), income from non-farm businesses (16.8 percent), sales of food crops (9.1 percent), Livestock & Poultry (8.1 percent), and wages (6.9 percent). Interestingly, the differences in income sources between poor and non-poor households are not very significant.

Due to regional variation in soil, climate, and infrastructure, the relevant sources of income may be different for households residing in different provinces. To see this, we report in Table 7.4 the main sources of agricultural household income in the rural areas of the nine Zambian provinces. The table shows the average share of total income accounted for by a given activity. We observe that in the Central, Eastern, and Southern provinces, the most relevant cash crop activity is cotton. In the remaining provinces, cotton is not a feasible option and income shares are negligible or zero. In the remaining of this paper, thus, we investigate the impacts of cotton reforms only in the relevant provinces.

Figure 7.1 displays the dynamics of cotton shares. We estimate the average cotton share conditional on household per capita income. These averages are estimated with non-parametric

locally weighted regressions. These are local linear regressions that weigh the data using kernel methods. We follow Fan (1992) and Pagan and Ullah (1999). We estimate a different non-parametric regression using data for 1996 and 1998.<sup>7</sup> The inspection of figure 7.1 provides details of the evolution of cotton as a cash crop in rural Zambia.

Both in 1996 and 1998, the cotton income shares increase at the very bottom of the income distribution and then decline with income. The maximum share is roughly over 10 percent. At the upper tail, the average share is quite small, of around 2 percent. As regards cotton dynamics, the average share is higher in 1998 at the bottom of the distribution (mostly poor households) and at its upper tail. In the middle of the income distribution, the cotton income share is higher in 1996 than in 1998.

It is instructive to look at the evolution of cotton shares across the different cotton-producing provinces. figures 2 to 4 plot the non-parametric averages for the Central, the Eastern, and the Southern provinces, respectively. In the Central province, for instance, cotton income shares in 1998 track the shares in 1996 at the bottom of the distribution, but become smaller at the middle. The Central province resembles the pattern at the national level, with higher average shares in 1998 at to bottom and at the top of the distribution, and lower shares at the middle. In contrast, cotton shares in the Southern province are higher across the entire income distribution in 1998 than in 1996.

The results in the previous figures indicate a regionally differentiated effect of the reforms on the pattern on income sources in rural Zambia. In particular, the increase in cotton shares in the Southern province is remarkable. Since this is the region that is perhaps closest to the capital, the result indicates that access to markets and infrastructure are key variables in adoption and in the deepening on cotton production.

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<sup>7</sup> Unfortunately, the 1991 Priority Survey does not include data on cotton income separately.

The link between these dynamics of cotton shares and the timing of the cotton reforms is straightforward. This would indicate that the increase in cotton shares, particularly among poorest farmers and in the Southern province, can be attributed to those reforms. This, however, does not necessarily follow. There are other factors simultaneously affecting cotton shares. Key factors include the collapse of the copper sector, the adoption of macroeconomic reforms, and the exogenous changes in international cotton prices. Given the available data, it is impossible for us to disentangle the contribution of these different factors to the observed trends in cotton shares. But we next argue that it is very likely that the marketing reforms are the major determinants.

The collapse of the copper sector (mainly due to a declining trend in international copper prices) is perhaps an urban phenomenon, rather than a rural phenomenon. In addition, copper is mainly associated with the Copperbelt province (where the copper mines and the industrial belt are located) and with Lusaka (the administrative center). It seems, therefore, that cotton producing provinces would be relatively unaffected by changes in the copper sector. It should be noticed, however, that the general equilibrium effects of the dramatic changes in a traditionally important sector of the Zambian economy cannot be ignored.

Similar remarks apply to the adoption of other economic policies. There is one important reform that has to be carefully considered, though. Zambia used to have a maize marketing board that set producer prices for maize grain and consumer prices for maize meals. As in cotton, the marketing board was eliminated as well. This is a major rural reform, and we should expect it to have significant effects on the allocation of agricultural resources and on cotton shares. Importantly, the maize reforms took place in 1993, well before the 1996-1998 period that we are investigating. Accordingly, we speculate that the effects of the maize reforms have already taken

place in 1996, the baseline period in our analysis.<sup>8</sup> To the extent, however, that these reforms have long-lasting effects on farmers, the observed dynamics in figures 7.1 to 7.4 will capture them.

There is another element that favors the role of the reform as a major determinant of cotton dynamics. An important observation is that the increase in cotton income shares is larger at the bottom of the distribution of per capita expenditure, i.e., among poorest households. If macroeconomic and aggregate shocks, with magnitudes that affect all households simultaneously, are size-neutral, then we shouldn't expect differences in the impacts at different points along the income distribution. This indicates, at least, that the relative changes in cotton dynamics are mostly generated by the marketing reforms. For instance, the larger increase in shares at the bottom of the distribution can be due to expanded access to seeds and fertilizers among the poor.

Finally, it is important to have in mind that cotton prices have continuously declined during this period. From 1996 to 1998, in particular, the real price of cotton in international markets has declined by as much as 20 percent.<sup>9</sup> There are two implications for our analysis. First, the dynamics in figures 7.1 to 7.4 show that cotton shares could have been even higher, in the face of the reform, had cotton prices been higher or remained stable. In other words, it would be reasonable to expect larger increases in cotton shares due to the cotton reforms if we could control for the change in cotton prices. Second, the decline in the real prices of agricultural

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<sup>8</sup>Similarly, the collapse of Zimbabwe has had significant impacts on the Zambian rural economy. It is observed, for instance, that tobacco has been increasingly adopted in Zambia, mainly due to the migration of neighboring peasants from Zimbabwe. However, the Zimbabwean crisis took place in recent years, after 1998, and should not affect our analysis.

<sup>9</sup>The decline around the long term trend seems to be, however, lower. See Food Security Research Project (2000).

products has been similar for other commodities such as maize, the major alternative crop in rural Zambia. This suggests that the changes in the price of cotton relative to maize has been mild.<sup>10</sup>

In summary, the available information prevents the econometric identification of the effects of the cotton reforms on the dynamics of cotton shares among Zambian farmers. But we have argued that the observed trends can be mostly linked to those reforms, and that the induced increase in cotton shares could have been larger. This is an interesting instance of a domestic policy that had crucial impacts on the farmers and on their ability to reap most of the benefits from further trade liberalization.

In what follows, we investigate the effects of the complementarities between domestic reforms and international agricultural liberalization on household welfare. As shown in section 2, international cotton markets are subject to strong intervention, particularly by developed countries. We begin by looking at the welfare effects of the increase in world prices that would take place if agricultural markets were liberalized. More concretely, we merge the analysis of cotton shares with increases in world cotton prices.

Define the household income as

$$y^h = \pi_c^h + \sum_j \pi_j^h,$$

where  $\pi_c^h$  is the income (profit) from cotton sales and  $\pi_j^h$  is income from activity  $j$  (wages, vegetables, maize, groundnuts, etc.). The change in income caused by an increase in the price of cotton  $p_c$  is

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<sup>10</sup>See Food Security Research Project (2000).

$$d\ln y^h = \theta_c^h d\ln p_c. \quad (1)$$

The proportional change in household income is given by the share of cotton income,  $\theta_c^h$ , multiplied by the proportional change in prices.

In section 2, we reviewed some evidence indicating that a full liberalization of agricultural markets along the lines of the Doha Round negotiations would bring about an increase in world cotton prices of around 12.7 percent. Similar results are obtained if we use the price increase predicted by Sumner (2004) of 11.6 percent. Using the data for 1998, we can estimate the average welfare effect given by equation (1). These averages, estimated again with a Fan regression, are shown in figure 7.5. We observe that the increase in prices would benefit farmers across the income distribution. The effects would range from over 0.75 to nearly 1.5 percent, at the bottom of the distribution, to roughly 0.5 percent at the top. The unconditional average gain would be around 1 percent of the initial household per capita income.

Figure 7.6 explores the regional differences in cotton gains. The solid line corresponds to the non-parametric average in the Central province; the broken line, to the non-parametric average in the Eastern province; and the dotted line, to the non-parametric averages in the Southern province. The figure shows that larger gains would take place in the Eastern province, particularly at the bottom of the distribution. In the Central province, the gains track the average gains in the Southern province at the bottom of the distribution; from the middle to the top, however, the gains in the Central province remain high, whereas the gains in the Southern province sharply decline with income.

These findings show that a 12.7 percent increase in the price of cotton would cause household income to increase, at most, by 1.5 percent (among the poorest households in the

Eastern province, for instance). Although these are positive effects associated with welfare gains, it is clear that the magnitudes are quite small. There are several reasons that help explain this fact.

As discussed in Section 2, the reforms in cotton markets have been relatively successful but have not been smooth. Initially, the public monopoly was transformed into a private monopoly. Entry was useful in early stages, but the failure of the outgrowing scheme limited the expansion of the sector. In fact, the outgrower scheme was still failing in 1998, when the household survey data was collected. This means that the evolution in income shares that we can capture with the available data does not reveal the whole benefits on the reforms.

Using additional farm data, Brambilla and Porto (2005) report that the cotton reforms had two distinctive effects on cotton farming. First, there is a decline of the land area devoted to cotton in 1998-1999 (when the outgrowing scheme was failing) followed by a significant increase in area planted in 2000-2001, when the outgrower scheme was perfected with the entrance of Dunavant. Second, the authors find that farm productivity in cotton showed a similar pattern, declining in 1998-1999 and increasing in 2000-2001. In addition, their findings indicate that income shares increased, on average, by roughly 10-20 percent. These additional factors could help increase the average gains from a 12 percent price increase to roughly 2 percent of household income, on average. Although these figures are higher, the effects seem still fairly low.

One additional reason for the small impacts is that cotton activities are not really widespread in Zambia. More importantly, we have only considered a first order approximation to the welfare gains. In the following section, we capture some supply responses and second round effects.

### 3. Cotton Production and Household Outcomes

In this section, we explore the impacts of cotton production on household outcomes. If free trade and cotton liberalization bring about renewed incentives for cotton production in Zambia, we expect farmers to switch from subsistence to cotton production (and, more generally, to market-oriented agriculture). In what follows, we explore these supply responses with the help of matching methods: by matching households in subsistence agriculture with households in cotton, we estimate the average effects of participating in cotton markets on several household outcomes. We focus on income differentials, children anthropometry, and education outcomes.<sup>11</sup>

#### 3.1 The Method

Our aim is to estimate the differences in outcomes linked to the production of a cash crop such as cotton, and to explore the poverty alleviation effects of allowing for an expansion of cotton activities among Zambian farmers. We use matching methods based on the propensity score.<sup>12</sup> We begin by estimating a probit model of participation into cotton, which defines the propensity score  $p(\mathbf{x})$ , for a given vector of observables  $\mathbf{x}$ . Subsistence farmers are matched with cotton farmers based on this propensity score, and the outcome differential is estimated using kernel methods.

Let us start with the income gains. Let  $y_h^m$  be the income per hectare in cotton of household  $h$ . Let  $y_h^s$  be the home produced own consumption per hectare. The average income differential (per hectare) for those involved in cotton production is defined as  $\tau = E[y_h^m - y_h^s | C=1]$ .

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<sup>11</sup>The estimation of supply responses has proved very difficult. The survey in Winters, McCulloch and McKay (2004) highlights these issues and reports some of the available methods and results. For the case of income gains, see Lopez, Nash and Stanton (1995) and Heltberg and Tarp (2001). For non-monetary outcomes, see Edmonds and Pavcnik (2004).

<sup>12</sup>Seminal papers on matching methods include Rubin (1977), Rosembaun and Rubin (1983), Heckman, Ichimura and Todd (1997) and (1998), Heckman, Ichimura, Smith and Todd (1996), and Dehejia and Wahba (2002).

Our task is to estimate the counterfactual quantity  $E[y_h^s|C=1]$ , the average return in subsistence agriculture among cotton farmers. We do this by using matching methods.

The main assumption of matching methods is that the participation into market agriculture can be based on observables. This is the ignorability of treatment assignment. Define an indicator variable  $C$ , where  $C=1$  if the households derive most of their income from cotton. In practice, most Zambian households in rural areas produce something for own consumption. As a consequence, we assign  $C=1$  to households that derive more than 50 percent of their income from cotton. Households that derive most of their income from home production are assigned  $C=0$ . The propensity score  $p(\mathbf{x})$  is defined as the conditional probability of participating in cotton,  $p(\mathbf{x})=P(C=1|\mathbf{x})$ .

The ignorability of treatment assignment requires that  $y_h^m, y_h^s \perp C | \mathbf{x}$ . When the propensity score is balanced, we know that conditional on  $p(\mathbf{x})$ , the participation in cotton  $C$  and the observables  $\mathbf{x}$  are independent. In other words, observations with a given propensity score have the same distribution of observables  $\mathbf{x}$  for households involved in cotton as in subsistence. The importance of the balancing property, which can be tested, is that it implies that, conditionally on  $p(\mathbf{x})$ , the returns in cotton and in subsistence are independent of market participation, which implies that households in subsistence and cotton are comparable.

The decision to participate in market agriculture depends on three main variables: access to markets, food security and risk, and tradition in subsistence agriculture. We capture these effects by including in the propensity function several key control variables like regional (district) dummies, the size of the household, the demographic structure of the family, the age and the education of the household head, and the availability of agricultural tools. We believe these variables  $\mathbf{x}$  comprise a comprehensive set of observables to explain the selection mechanism.

Once the propensity score is estimated, we test the balancing condition. This requires partitioning the estimated  $p(\mathbf{x})$  and testing that, within each stratum, the mean and variances of the covariates are not statistically different.<sup>13</sup> In the current case of cotton, the balancing property was always satisfied.<sup>14</sup>

### 3.2 Monetary Outcomes

In this paper, we investigate a constrained model of household agricultural production. This means that households are assumed to face significant constraints in terms of land, family labor supply, or inputs. This means that there would be forgone income by expanding cash crop activities. In this model, thus, if a family were to plant an additional acre of cotton, then an acre of land devoted to own-consumption (and all other relevant resources) should be released.

Table 5 reports the results. The first column shows the gains per hectare. In the second column, the constrained household is assumed to expand cotton production by the average size of the plots devoted to cotton in Zambia. Our results indicate that there are gains from cotton production: farmers growing cotton are expected to gain 18,232 kwachas, on average, more than similar farmers engaged in subsistence agriculture. The gain is equivalent to 19.9 percent of the average expenditure of a representative poor farmer. To get a better sense of what these numbers mean, notice that the food poverty line in 1998 was estimated at Kw 32,233 per month and the poverty line, at 46,287 per month (per equivalent adult). Further, since the exchange rate in December 1998 was around 2,200Kw, the gains are equivalent to just over 8 US dollars (in 1998 prices).

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<sup>13</sup>In general, this involves setting up a series of F-test for the equality of means, for instance. See Dehejia and Whaba (2002) for more details.

<sup>14</sup>The balancing property is a minor requirement that we impose in our procedure. In many applications, the property is not necessarily satisfied. In Balat and Porto (2004), for example, we found that the balancing did not hold in cases including cassava or sunflowers. Notice that we cannot test the ignorability requirement, which is an assumption of the matching method.

The actual gains will depend on the land area allocated to cotton. If farmers are allowed to plant the average size of a typical cotton plot, which is estimated at 1.2 hectares, the estimated gains increase to Kw 21,878. This is equivalent to 23.9 percent of the income of the poor. Notice that since the average size of the land plots allocated to home production ranges from 1.5 to 5 hectares, with an unconditional average of around 2 hectares, it would be feasible for an average household to switch from own-consumption to cotton growing activities.

Our matching results suggest that there might be additional gains from switching to cotton. A natural question is why these opportunities are not exploited by the farmers. While there are many reasons that can explain this fact, we want to emphasize here the key role of complementary policies. Access to international markets is a basic prerequisite. This requires openness and export oriented incentives on behalf of Zambia, but also a liberalization of agricultural markets in developed countries. Price and income support, and export and input subsidies should be eliminated. But other domestic complementary policies should be implemented as well. We identify several key policies. Extension services to farmers, including transmission of information and know-how about cropping, crop diversification, fertilizer and pesticide use, etc., are critical. The provision of infrastructure to reduce transport and transaction costs is also essential. Irrigation may also help. The development of a stronger financial and credit market can also help farmers reduce the costs of the outgrower programs. Finally, education (both formal education and labor discipline) and the provision of better health services will surely help increase farm productivity in cotton.

It is generally difficult to assess the role of complementary policies empirically. But we are in a position to provide some sense of their importance by looking at pieces of evidence reported in the related literature. In Brambilla and Porto (2005), for example, the authors find that farmers that received extension services are 8.4 percent more productive in cotton than farmers

that did not receive any technical assistance. *Ceteris paribus*, this would imply a 8.4 increase in household well-being. This clearly shows that complementary policies can indeed be useful to improve the living conditions of poor farmers in rural Zambia.

In our view, the role of Doha is not only to provide a higher price for cotton, but also to facilitate market access. Complementary policies can help farmers to fully exploit these opportunities. So far, we have explored the effects of increasing prices on household income, and we have provided a quantification of the potential gains of switching from subsistence to cotton. We think of Doha and the complementary policies as vehicles to make these gains feasible. To look at these links more closely, we perform the following experiment. The increase in prices caused by the Doha development round would induce an expansion of quantities produced. If these quantities could be produced and sold by Zambian farmers, then the realization of the gains becomes feasible.

To quantify these effects, we proceed as follows. First, there is some quantity changes induced by Doha. This could be estimated, for instance, by multiplying the price changes reported in section 2 by an export supply elasticity. As an example, if this elasticity were one, an increase in price of 12.7 percent would cause quantities to react by 12.7 percent too.<sup>15</sup> Given these quantity changes, the issue is how to allocate them to the different households. To do this, notice that the estimated propensity score indicates the probability of being a cotton producer. One reasonable scenario is thus to allocate the quantity changes on the basis of the relative propensity score. It is important to notice that by proceeding in this way, we are allowing households in subsistence to switch to some production of cotton. However, this switch can be minor if the relative probability is small for particular farmers. In addition, farmers that are

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<sup>15</sup>See Hoekman, Nicita, and Olarreaga (2004) for an nice attempt along these lines.

already producing cotton are more likely to have higher estimated probabilities, which can make them better candidates to absorb larger fractions of the export opportunities.

Figure 7.7 plots the average relative probability of being a cotton producer across the income distribution. The curve is estimated with non-parametric methods, as before. We see that the relative probability, and therefore the gains from any expansion in quantities, slightly increases with income at the bottom of the distribution and then remains relatively constant. We interpret this finding as indicating that everyone across the entire income distribution would benefit about the same from the Doha market opportunities.

In figure 7.8, we plot the relative probabilities for the three provinces. As before, the solid line corresponds to the case of the Central province, the broken line, to the Eastern province, and the dotted line, to the case of the Southern province. Although there are differences in the level of the relative probability across provinces (that should resemble the regional differences in the likelihood of cotton production), the distributional effects are the same in all three provinces. No discernible differences across the income distribution can be expected.

It is tempting to use this framework to allocate the potential export opportunities brought about by Doha across Zambian farmers and to identify households that would actually switch from subsistence to cotton. In addition, it would be possible to guess how much substitution would take place for different households. To do this, however, we need to recourse to ad-hoc rules that would dictate the pattern of agricultural switching. While some interesting attempts to do this (in the context of labor markets) are being developed, here we have decided to report only the estimated relative probabilities of switching. This approach provides estimates of expected gains, which is as far as we can go with the available data and methods. It has the virtue of being based on estimates derived from econometric models rather than from ad-hoc rules.

Nevertheless, we can use our estimates to shed additional light on the impacts of Doha and complementary reforms in Zambia. As reported in Table 5, the estimated gain from switching from subsistence agriculture to cotton would be 19.9 percent. This is a measure of the gains from switching, even in the absence of trade reforms. The price effect (roughly a 12.7 percent increase in cotton prices due to trade reforms) would cause the average income of a cotton producer to increase by approximately 1 percent (figure 7.6). If trade reforms induce a switch from subsistence to cotton, then the gains of a switcher would be of about 20.9 percent (19.9 percent due to higher cotton returns plus 1 percent due to higher prices). An expansion of quantities produced and exported (supply responses) would generate additional gains. An example would be the productivity gains of around 8.4 percent (Brambilla and Porto, 2005) induced by successful extension services and made feasible by world markets (through Doha). The average income of a cotton producer would increase by 9.4 percent and that of a subsistence farmer by 29.3 percent. We can conclude, thus, that although the price effect of trade reforms (tariffs plus subsidies in cotton) would be generally small, the combination of new market opportunities and domestic reforms (so that switching and productivity gains become viable) can work as very effective vehicles for poverty alleviation.

### **3.3 Non-Monetary Outcomes**

We turn now to the non-monetary effects of cotton production. We look at the effects on two household outcomes, namely the nutritional status of infants and young children (from 0 to 60 months old) and education performance of children in primary and secondary school.

Malnutrition remains a widespread problem in developing countries, as does in Zambia. We assess the nutritional status on the basis of anthropometric indicators (such as height or

weight). We analyze the three most commonly used anthropometric indicators for infants and children: weight-for-age, height-for-age, and weight-for-age.

Weight-for-height (whz) measures body weight relative to height. It is normally used as an indicator of current nutritional status, and can be useful for measuring short-term changes in nutritional status. Extreme cases of low whz relative to a child of the same sex and age in a reference population are commonly referred to as “wasting”. Wasting may be the consequence of starvation or severe disease (in particular diarrhea), but it can also be due to chronic conditions. Height-for-age (haz) reflects cumulative linear growth. haz deficits indicate past or chronic inadequacies nutrition and/or chronic or frequent illness, but cannot measure short-term changes in malnutrition. Extreme cases of low haz are referred to as “stunting”. Weight-for-age (waz) reflects body mass relative to age. This is, in effect, a composite measure of height-for-age and weight-for-height, making interpretation difficult. The term “underweight” is commonly used to refer to severe or pathological deficits in waz.

A problem arises as weight and height depend on both age and gender (and other factors such as genetic variation) but it is possible to use physical measurements by comparing indicators with the distribution of the same indicator for a “healthy” reference group. In this way we use z-scores (standard deviation scores) which is the most common way of expressing anthropometric indices.<sup>16</sup> Table 6 presents some summary statistics.

The value of the mean of the haz z-score is  $-2.21$ , reflecting long-term cumulative inadequacies of health and/or nutrition.<sup>17</sup> There seems to be no wasting problem, the mean of whz is  $0.23$ . Using the summary measure of nutritional status (waz) there is mild underweight, probably caused by long-term nutritional problems.

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<sup>16</sup>A z-score is defined as the difference between the value for an individual and the median value of the reference population for the same age or height, divided by the standard deviation of the reference population.

<sup>17</sup>The WHO uses a z-score cut-off point of  $-2$  to classify low weight-for-age, low height-for-age and low weight-for-height as moderate and severe undernutrition, and  $-3$  to define severe undernutrition.

For the education outcome, we generated an index of school performance for children between ages 7 and 18, that is, children in primary and secondary school. The index is the ratio of years of education completed by an individual and the years of education this individual should have for his age.<sup>18</sup> The mean of this index for rural areas is 0.49 including children not attending school (approximately 45% of the sample).

We now describe the exercises performed using the same matching methods as before. We want to assess the effects of participation in cotton production in other dimensions than monetary income. We estimate the effects on child nutrition and education of a switching from subsistence to cotton. Table 7 reports the results.

We estimate differences in outcomes for the sample of all infants and young children (0 to 59 months old), for the subsample of males, and for the subsample of females. Interestingly, we find statistically significant effects only in terms of stunting, or long-run nutritional gains. On average, a cotton family would enjoy a higher z-score of 0.64 points. This is equivalent to 30 percent of the average haz z-score for households in subsistence. There are no significant differences in wasting and underweight between cotton and subsistence households. Also, there is no differential effect between females and males, although the magnitudes for males are much larger and marginally significant. Similar results have been found in, for example, von Braun and Kennedy (1994).

These are very interesting results. They indicate that there are no differences in current nutrition among children living in cotton producing or subsistence households. However, there are statistically significant benefits in terms of long-term nutrition among those children living in cotton farms. One interpretation is that whereas doing cotton or subsistence allows children to be

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<sup>18</sup>Then, for an individual with no education the index takes a 0 and if she is in the grade that corresponds to her age the index takes 1.

currently well fed, through the consumption of maize or sweet potatoes for instance, cash income derived from cotton would allow farmers to purchase milk, fish, or dairy products that have longer term benefits. Another hypothesis argues that the movement from subsistence to agricultural commercialization implies a change in the use of fertilizers and pesticides that helps prevent health hazards and improve the long-term nutritional status of the children.

In the case of education, our findings indicate that educational outcomes are similar in households involved in cotton and in households involved in subsistence. This result holds for the whole population (all children between 7 and 18 years old), children in primary school and children in secondary school.

#### **4. Conclusions**

In this paper, we have examined the relationship between cotton reforms and poverty in Zambia. Cotton is one of the main cash crops of smallholders in suitable provinces in rural Zambia. Further, rural poverty is pronounced and widespread. The sector has experienced significant reforms that implied a movement from a publicly controlled parastatal firm, to privatization and competition. In this context, cotton is claimed to be a major market agricultural activity for vulnerable families in rural areas.

We have explored two angles of the cotton-poverty connection. On the one hand, we have simulated the welfare effects that would take place if agricultural cotton markets were liberalized and world price would thereby increase. On the other hand, we have estimated the differences in several outcomes between households involved in cotton and households involved in subsistence agriculture.

Our first finding shows that the domestic reforms have caused cotton shares to increase at the bottom of the income distribution. These are poor farmers. Regarding international market

access, we estimate that the increase in world price would benefit cotton producers across the entire income distribution. An estimated 12.7 percent increase in prices would bring about welfare gains reaching roughly 1 percent of household income. In addition, we find that households involved in cotton enjoy income gains over households involved in subsistence. This implies that a movement from subsistence to market agriculture would benefit rural farmers and would lead to a further decline in poverty rates. After world trade reforms, for instance, the welfare gain of a switcher was estimated at approximately 21 percent. Further, productivity gains induced by extension services (improved during the marketing reforms) and made feasible by expanded international markets (due to Doha) would lead to welfare gains of 9 percent, among cotton producers, and 30 percent, among switchers. In terms of non-monetary outcomes, we find higher long-run nutritional status among children residing in cotton producing farms, but no significant differences in educational attainments.

We believe that our results highlight promising avenues for poverty alleviation through cash agricultural activities such as cotton. It is important to notice that the estimated magnitudes are relatively small. This shows that to take full advantage of the access to international markets (with a liberalization of world agricultural markets), complementary policies are essential. These policies include extension services (information), infrastructure (transport), irrigation, access to credit and finance, education, and health services.

## References

- Aksoy, A. and J. Beghin, eds. 2004. *Global Agricultural Trade and Developing Countries*. Washington, DC: World Bank.
- Baffes, J. 2004. "Cotton: Marketing Setting, Policies, Issues, and Facts." In Aksoy and Beghin eds. 2004.
- Balat, J. and G. Porto. 2004. "Globalization and Complementary Policies. Poverty Impacts in Rural Zambia." In A. Harrison ed. 2004.
- Brambilla, I., and G. Porto. 2005. "Farm Productivity and Market Structure. Evidence From Cotton Reforms in Zambia." Mimeo, Yale University.
- Cotton News. 2002. *Cotton Development Trust*. Lusaka: Zambia.
- Deaton, A. 1989. "Rice Prices and Income Distribution in Thailand: a Non-Parametric Analysis." *Economic Journal* 99: 1-37.
- Deaton, A. 1997. *The Analysis of Household Surveys. A Microeconomic Approach to Development Policy*. Baltimore and Washington DC: John Hopkins University Press for the World Bank.
- Dehejia, R., and S. Wahba. 2002. "Propensity Score Matching Methods for Non-Experimental Causal Studies." *Review of Economic Studies* 84(1): 151-161.
- Edmonds, E. and N. Pavcnik. 2004. "The Effects of Trade Liberalization on Child Labor." forthcoming *Journal of International Economics*.
- Fan, J. 1992. "Design-adaptive nonparametric regression." *Journal of the American Statistical Association* 87(420): 998-1004.
- FAPRI (Food and agricultural Policy Research Institute). 2002. "The Doha Round of the World Trade Organization: Liberalization of Agricultural Markets and its Impacts on Developing Economics." Mimeo.
- FSRP (Food Security Research Project). 2000. "Improving Smallholder and Agribusiness Opportunities in Zambia's Cotton Sector: Key Challenges and Options." Working Paper No 1. Lusaka: Zambia.
- Harrison, A. ed. 2004. *Globalization and Poverty*. Boston, Massachusetts: National Bureau of Economic Research.
- Heckman, J., H. Ichimura, J. Smith, and P. Todd. 1996. "Sources of Selection Bias in Evaluating Social Programs: An Interpretation of Conventional Measures and Evidence on the Effectiveness of Matching as a Program Evaluation Method." *Proceedings of the National Academy of Sciences* 93(23): 13426-13420.
- Heckman, J., H. Ichimura, and P. Todd. 1997. "Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme." *Review of Economic Studies* 64(4): 605-654.
- Heckman, J., H. Ichimura, and P. Todd. 1998. "Matching as an Econometric Evaluation Estimator." *Review of Economic Studies* 65(2): 261-294.

- Heltberg, R. and F. Tarp. 2001. "Agricultural Supply Response and Poverty in Mozambique." Mimeo.
- Hoekman, B., A. Nicita, and M. Olarreaga. 2004. "Can Doha Deliver the Development Round?" Mimeo, World Bank.
- Litchfield, J. and N. McCulloch. 2003. "Poverty in Zambia: Assessing the Impacts of Trade Liberalization in the 1990s." Mimeo, Poverty Research Unit, Sussex University.
- Lopez, R., J. Nash and J. Stanton. 1995. "Adjustment and Poverty in Mexican Agriculture. How farmers' wealth Affects Supply Response." Policy Research Working Paper No 1494, the World Bank.
- McCulloch, N., B. Baulch, and M. Cherel-Robson. 2001. "Poverty, Inequality and Growth in Zambia During the 1990s." Presented at WIDER Development Conference, Helsinki, May 2001.
- Pagan, A. and A. Ullah (1999). *Nonparametric Econometrics*. New York: Cambridge University Press.
- Rosenbaum, P., and D. Rubin. 1983. "The Central Role of the Propensity Score in Observational Studies of Causal Effects." *Biometrika* 70(1): 41-55.
- Rubin, D. 1977. "Assignment to a Treatment Group on the Basis of a Covariate." *Journal of Educational Statistics* 2(1): 1-26.
- Sumner, D. 2004. "The Doha Cotton Initiative." Mimeo, University of California.
- von Braun, J. and E. Kennedy. eds. 1994. *Agricultural Commercialization, Economic Development, and Nutrition*. Baltimore and London: John Hopkins University Press for the International Food Policy Research Institute.
- Winters, A., N. McCulloch, and A. McKay. 2004. "Trade Liberalization and Poverty: The Evidence So Far." *Journal of Economic Literature* XLII: 72-115.
- World Bank. 1994. *Zambia Poverty Assessment*. Washington DC: World Bank.

**Table 7.1: Poverty in Zambia**  
(head count)

	1991	1996	1998
National	69.6	80.0	71.5
Rural	88.3	90.5	82.1
Urban	47.2	62.1	53.4

Note: The head count is the percentage of the population below the poverty line. Own calculations based on Priority Survey (1991), Living Conditions Monitoring Survey (1996) and Living Conditions Monitoring Survey (1998).

**Table 7.2: Rural Poverty Trends  
1991-1996-1998**  
(head count)

	1991	1996	1998
National	88.3	90.5	82.1
Central	83.9	80.3	82.3
Copperbelt	66.2	78.8	82.1
Eastern	92.0	85.5	80.6
Luapula	90.8	86.1	84.6
Lusaka	70.9	78.1	75.7
Northern	94.2	90.6	83.3
North-Western	86.3	87.3	77.4
Southern	85.4	82.5	73.0
Western	94.1	92.9	90.3

Note: Rural Poverty only. The head count is the percentage of the population below the poverty line. Own calculations based on Priority Survey (1991), Living Conditions Monitoring Survey (1996) and Living Conditions Monitoring Survey (1998).

**Table 7.3: Sources of Income in Rural Areas – 1998**  
(percentage)

	total	poor	non-poor
Own Production	42.5	42.9	42.0
Sales of Food Crops	9.1	9.5	7.6
Sales on non-Food Crops	3.8	4.0	2.9
Livestock & Poultry	8.1	8.7	5.9
Wages	6.9	5.9	10.3
Income non-farm	16.8	16.3	18.3
Remittances	5.3	5.0	6.1
Other sources	7.5	7.7	6.9
	100.0	100.0	100.0

Note: The table reports income shares in rural areas. Own calculations based on Living Conditions Monitoring Survey (1998).

**Table 7.4: Income Shares From Agricultural Activities**  
Rural Zambia (1998)

Province	1	2	3	4	5	6	7	8	9	Total
Cotton	8.4	0	9.5	0	0.8	0	0.1	2.8	0.2	3.1
Vegetables	1.1	2.8	0.3	0.2	1.2	0.7	0.5	1.7	0.3	0.8
Tobacco	0.2	0.1	2.3	0	0	0	0.1	0.2	0.1	0.5
Groundnuts	0.9	0.7	2.4	2	0.2	1.4	1.1	0.4	0.2	1.2
Paprika	0	0	0.1	0	0	0	0	0	0	0
Industrial maize	6.1	2	0.7	0.3	1.7	0.6	0.3	1.4	0.5	1.3
Cassava	0.3	0.2	0.1	4.1	0	2.4	2.2	0.1	1.3	1.2
Maize	4.4	3.1	3.2	0.5	1.1	0.9	3.8	0.9	2.6	2.2
Rice	0	0	0.3	0.1	0	0.1	0	0	1.2	0.2
Millet	0.9	0.1	0.2	0.3	0	1.3	0	0	0.2	0.4
Sorghum	0.1	0.2	0	0	0.1	0.2	0.5	0	0.2	0.1
Beans	0.2	0.1	0	0.5	0	2	0.8	0	0	0.5
Soya beans	0.4	0	0.4	0.1	0	0	0	0	0	0.1
Sweet potatoes	0.9	2.8	0.1	1	0	0.3	1.6	0.1	0.5	0.7
Irish potatoes	0	0.1	0	0.1	0	0	0.3	0.1	0	0.1
Sunflower	0.1	0	0.5	0	0	0.1	0.1	0.2	0	0.1
Livestock	2.9	1.3	4.3	0.6	3.8	2	2.3	8	6.9	3.8
Poultry	6.4	2.2	4.5	2.7	5.9	3.4	2.8	4.6	6.7	4.3

Note: Income shares are in percentage. Provinces are indexed as follows. 1: Central, 2: Copperbelt, 3: Eastern, 4: Luapala, 5: Lusaka, 6: Northern, 7: North-Western, 8: Southern, 9: Western. Own calculations based on Living Conditions Monitoring Survey (1998).

**Table 7.5: Income Gains from Cotton Production**

	Constrained Model (per ha)		Constrained Model	
		% of expenditure		% of expenditure
Cotton	18232 (7456)	19.9	21878 (8947)	23.9

Note: Results from propensity score matching of cotton farmers and subsistence farmers using kernel methods. Standard errors in parenthesis are estimated with bootstrap methods. The Constrained Model (per ha) assumes that the household has to give up one hectare of land to produce an additional hectare of cotton. The Constrained Model assumes that the farmer moves from subsistence to cotton and allocates the average plot size of cotton farmers (1.2 hectares).

**Table 7.6: Child Nutrition in Rural Areas**  
(0 to 59 months old)

	z-score		Prevalence rates	
	mean	sd	moderate	severe
stunting (haz)	-2.21	1.77	23%	33%
wasting (whz)	0.23	1.40	5%	1%
underweight (waz)	-1.21	1.24	20%	6%

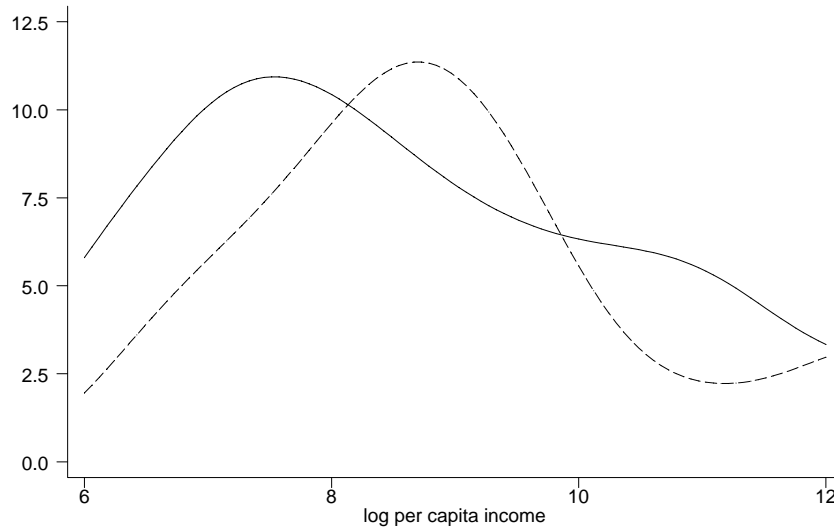
Note: Height-for-age (haz) is a measure of accumulated undernutrition. Weight-for-height (whz) is used to measure levels of current undernutrition. Weight-for-age (waz) is used as a summary measure of nutritional status. In medicine, the prevalence rate is the proportion of individuals suffering a disease. Moderate refers to those individuals with a z-score between -3 and -2, and severe refers to a z-score below -3.

**Table 7.7: Effects on Child Nutrition and Education from Market Agriculture**  
Cotton versus Subsistence

	Total			Males			Females		
	stunting (haz)	wasting (whz)	underwt. (waz)	stunting (haz)	wasting (whz)	underwt. (waz)	stunting (haz)	wasting (whz)	underwt. (waz)
	0.64 (0.34)	-0.004 (0.33)	0.34 (0.24)	1.07 (0.63)	-0.25 (0.52)	0.45 (0.45)	0.14 (0.85)	-0.004 (0.66)	0.07 (0.37)
	Total			Males			Females		
	All	primary	secondary	all	primary	secondary	all	primary	secondary
	-0.02 (0.04)	-0.01 (0.05)	0.01 (0.05)	-0.03 (0.04)	-0.07 (0.06)	-0.02 (0.07)	0.01 (0.05)	-0.01 (0.07)	0.13 (0.10)

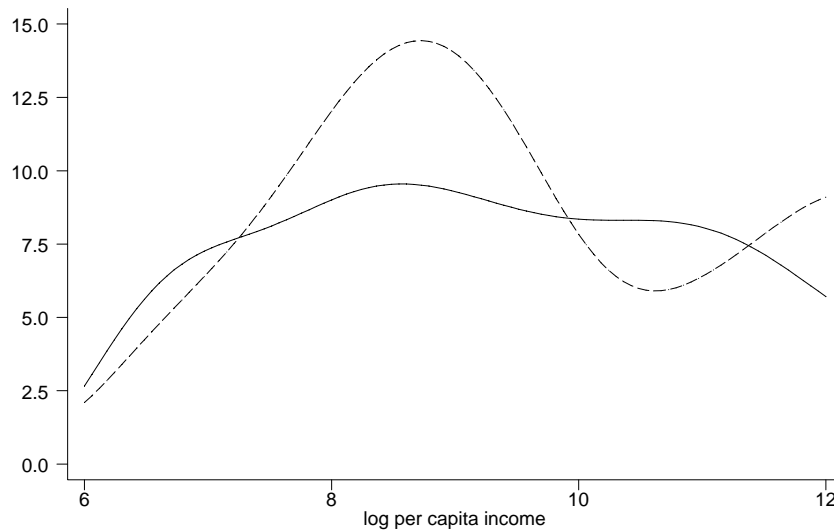
Note: Results from propensity score matching of cotton farmers and subsistence farmers using kernel methods. Standard errors in parenthesis are estimated with bootstrap methods.

Figure 1  
Dynamics of Cotton Income Shares



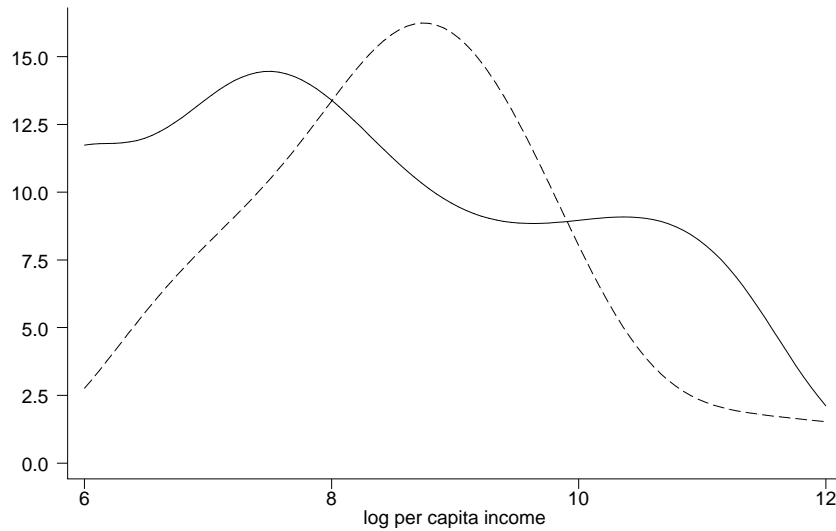
Note: The graph shows the average cotton income shares in total income. These averages are estimated with non-parametric regressions (Fan, 1992; Pagan and Ullah, 1999). The solid curve corresponds to cotton shares in 1998 and the broken line to the shares in 1996. Own calculations based on the Living Conditions Monitoring Surveys of 1996 and 1998.

Figure 2  
Dynamics of Cotton Income Shares  
Central Province



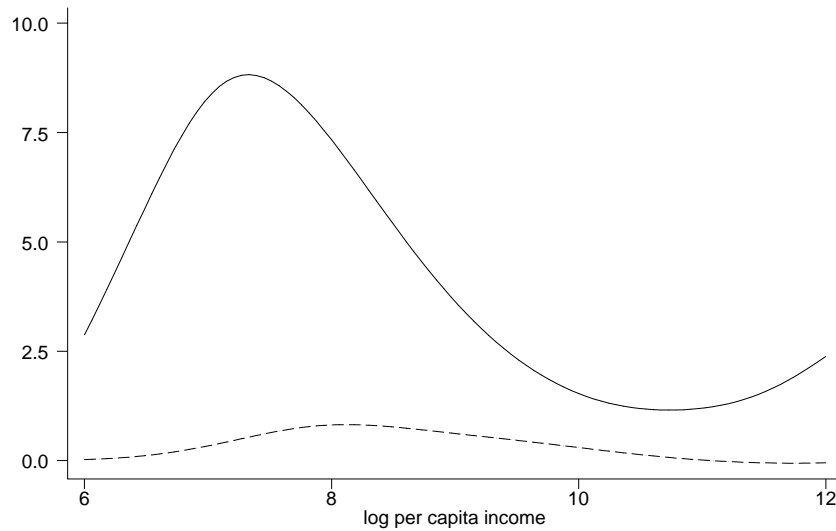
Note: The graph shows the average cotton income shares in total income. These averages are estimated with non-parametric regressions (Fan, 1992; Pagan and Ullah, 1999). The solid curve corresponds to cotton shares in 1998 and the broken line to the shares in 1996. Own calculations based on the Living Conditions Monitoring Surveys of 1996 and 1998.

Figure 3  
Dynamics of Cotton Income Shares  
Eastern Province



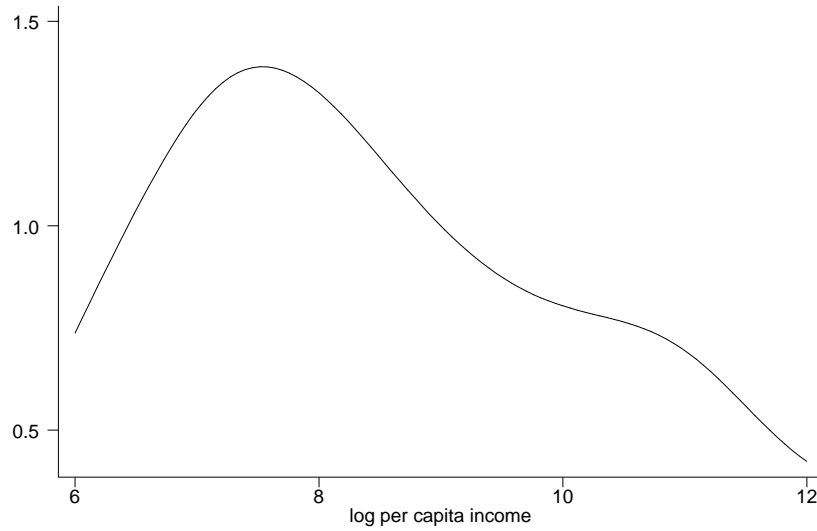
Note: The graph shows the average cotton income shares in total income. These averages are estimated with non-parametric regressions (Fan, 1992; Pagan and Ullah, 1999). The solid curve corresponds to cotton shares in 1998 and the broken line to the shares in 1996. Own calculations based on the Living Conditions Monitoring Surveys of 1996 and 1998.

Figure 4  
Dynamics of Cotton Income Shares  
Southern Province



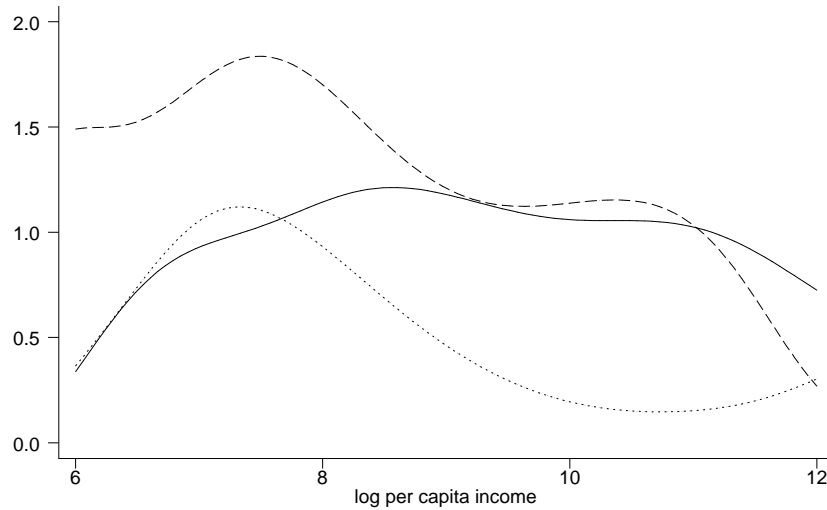
Note: The graph shows the average cotton income shares in total income. These averages are estimated with non-parametric regressions (Fan, 1992; Pagan and Ullah, 1999). The solid curve corresponds to cotton shares in 1998 and the broken line to the shares in 1996. Own calculations based on the Living Conditions Monitoring Surveys of 1996 and 1998.

Figure 5  
Cotton Prices and Household Income



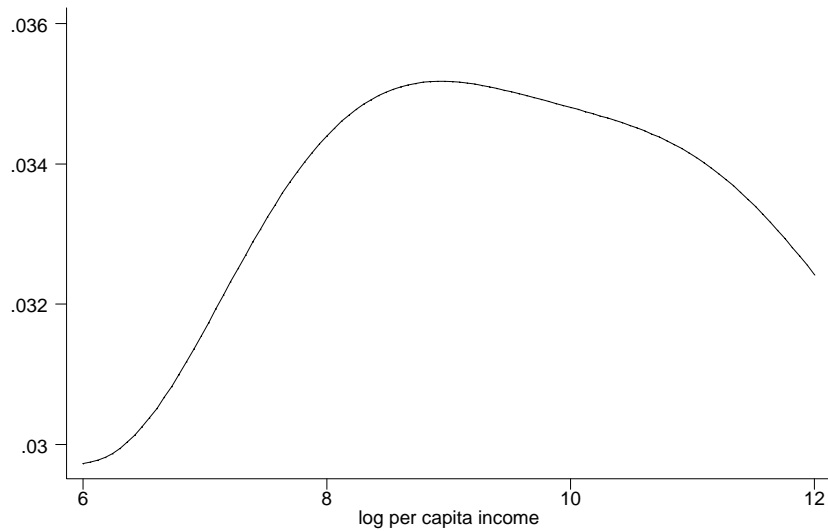
Note: The graph shows the average welfare effects (defined as the cotton shares multiplied by the change in world cotton prices) at different levels of household per capita income. The curves are estimated with non-parametric locally weighted regressions (Fan, 1992; Pagan and Ullah, 1999). The calculations are based on the Living Conditions Monitoring Survey 1998.

Figure 6  
Cotton Prices and Household Income  
Regional Analysis



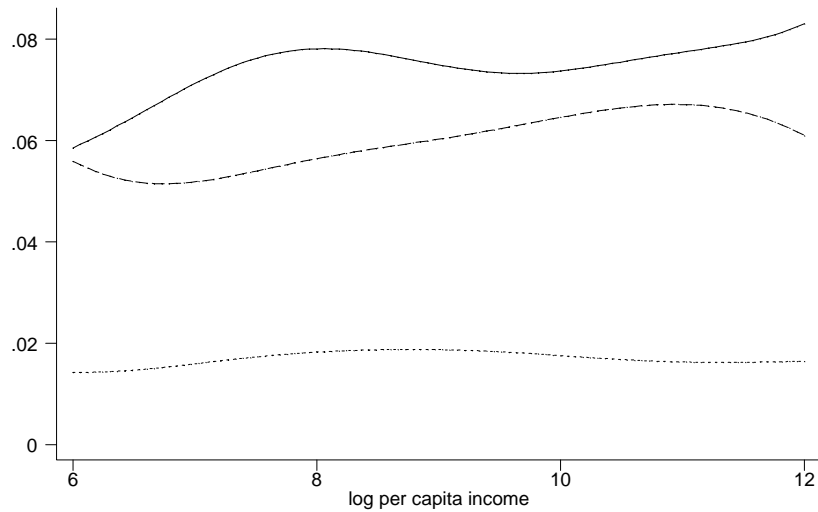
Note: The graph shows the average welfare effects (defined as the cotton shares multiplied by the change in world cotton prices) at different levels of household per capita income for the three cotton-producing provinces. The curves are estimated with non-parametric locally weighted regressions (Fan, 1992; Pagan and Ullah, 1999). The solid, broken and dotted lines corresponds to the Central, Eastern, and Southern provinces respectively. The calculations are based on the Living Conditions Monitoring Survey 1998.

Figure 7  
Relative Probability of Cotton Production



Note: The graph shows the average relative probability of being a cotton producer at different levels of household per capita income. The curves are estimated with non-parametric locally weighted regressions (Fan, 1992; Pagan and Ullah, 1999). The calculations are based on the Living Conditions Monitoring Survey 1998.

Figure 8  
Relative Probability of Cotton Production  
Regional Analysis



Note: The graph shows the average relative probability of being a cotton producer at different levels of household per capita income for the three cotton-producing provinces. The curves are estimated with non-parametric locally weighted regressions (Fan, 1992; Pagan and Ullah, 1999). The solid, broken and dotted lines corresponds to the Central, Eastern, and Southern provinces respectively. The calculations are based on the Living Conditions Monitoring Survey 1998.