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FUTURE POTENTIAL OF BRAZILIAN COTTON EXPORTS

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Abstract

An Acreage Allocation model of the type developed by Holt (1999) is applied to the four most important Brazilian field crops (cotton, soybeans, corn and rice) in Brazil's new and expanding cotton producing states of Mato Grosso and Goais. Cotton acreage response to additional field crop land (scale effect) and own and cross crop price elasticities are estimated. Results indicate that Goais has a higher scale elasticity than Mato Grosso (0.75 versus 0.61), and that cotton acreage is significantly affected by own price and corn price behavior, but not by soybean and rice prices. Baseline projections indicate that cotton acreage in Brazil's new cotton producing region will grow at a slower rate than total world acreage from 2003 to 2008, and at a faster from 2009 to 2013. However, Brazil's total cotton production is projected to grow more rapidly than the world average if Brazil's cotton yields increase at their historical trend, but total production growth will be similar to the World's if Brazil's cotton yields remain constant.

Introduction

The United States is the world's largest exporter of cotton accounting for 25% of world exports in the 1990's. Six countries account for forty percent of the world's cotton imports: The European Union (EU), Indonesia, China, Brazil, South Korea and Thailand. The United States exports to all these major markets, however, U.S. exports to the EU and Brazil represent only a small proportion of total cotton imports by these two countries. The world's four largest producing and consuming countries are China, the United States, India and Pakistan, which collectively account for 60% of world cotton production and consumption. The next three largest consuming countries are Turkey, Brazil and Mexico, all of which also produce cotton but are often large importers (USDA-ERS, 2002b).

For decades Brazil has been a major cotton producing, consuming and exporting country. Throughout the 1970's and 80's Brazil was a net cotton exporter, but by 1991 domestic cotton production was inadequate to satisfy domestic demand, and Brazil became a net importer. Brazil's importation of cotton increased throughout the early and mid 1990's, and reached a peak in 1996, when Brazilian cotton production was 305, 906 MT, more than 56% less than the 700,000 MT Brazil produced in 1991.

A recent USDA-ERS study states that the level of future U.S cotton exports will depend on two crucial factors: (1) consumption gains in markets relying largely on imported cotton like Mexico and Southeast Asia, and (2) the degree to which cotton producers like China, Turkey, and Brazil rely on imports rather than domestic production to meet the growing needs of their textiles industries (USDA-ERS, 2000). Brazil is now viewed as a sleeping giant with the potential to become a major competitor to U.S. Cotton exports in international markets. Brazil has more than 89 million hectares of uncultivated land in the Cerrado Savannah, located in the Brazil's central plateau region, rich in water resources with ideal climatic and agronomic conditions for cotton production.

Structural Change

Beginning in 1996, the Brazilian cotton sector has undergone a radical transformation. Cotton production substantially declined in the traditional producing regions of South and Northeast Brazil, and rapidly expanded into the Cerrado Savannah. Various factors motivated the shift of cotton production from the traditional south and northeast regions to the extensive Cerrado Savannah area of central Brazil. The most important factors were the development of new technologies for managing cerrado soil, advances in crop varieties, Cerrado's cheap and abundant land and water resources, ideal climatic and agronomic conditions, large parcels of land suitable for large highly mechanized crop production, and government incentives to expand the agricultural frontier in this new region. Another crucial factor facilitating cotton expansion is the extremely high cotton yields in the new region.

The Cerrado Savanna consists of 207 million hectares and totally or partially encompasses 9 of the 27 Brazilian states (Mato Grosso, Mato Gross do Sul and Goais, Rondonia, Minas Gerais, parts of Bahia, Tocantis, Piaui and Maranhao), all of which share common agricultural conditions and characteristics. To date, only 47 million hectares of the Cerrado Savannah has been brought into agricultural production, but EMPRAMPA, Brazil's Agricultural Research Organization estimates that another 89 million hectares could be developed for large scale, mechanized agriculture in the near feature. This potential new acreage is greater than the combined U.S. area of corn, soybeans, wheat, and feed grains (http://agbrazil.com/brazil_s_agriculture_frontier.htm). Within the Cerrado Savanna, cotton production is now heavily concentrated in the states of Mato Grosso and Goais, however, the seven other states spanned by the Cerrado Savannah have significant acreage suitable for large scale cotton production. This analysis is limited to the states of Mato Grosso and Goais, and collectively refers to these two states as the new or emerging Brazilian cotton producing region. Between 1996/97 and 2000/01 cotton acreage planted in these two states increased from 125,000 hectares to 520,000 hectares, and now represents 58% of the Brazil's total cotton acreage. Cotton production in this new region increased from 104,000 MT in 1996/97 to 645, 000 MT in 2000/2001 (Figure 1), rising from a 34% share of total production in 1996/97 to 69% share in 2000/2001. This rapid expansion allowed Brazil to become cotton self-sufficient in 2001, with a production volume of 938, 000 MT, and a net exporter in 2002.

In both the traditional and new regions, cotton competes for agricultural resources with other major field crops such as soybeans, corn, rice and wheat. Similarly, these crops compete with pasture, food crops and livestock activity. The two regions (traditional and new) are distinguished by differences in climate, cropping patterns and other farm characteristics, particularly farm size (Scneph, et. al.). The traditional region, being closer to the country's urban centers and major ports, has an advantage in transportation and marketing infrastructure relative to the new region. A major disadvantage of the traditional region is that small farm size has inhibited economies of scale and large mechanization. Even though the new region has a less developed infrastructure, the existence of larger, more mechanized farms has allowed the advance of economies of scale and technological developments, increasing production efficiency and yielding higher per hectare yields. Average cotton yield was 1.36 MT/HA in Mato Grosso in 2001 compared to an average yield of 1.01 MT/HA in the traditional area (Figure 2). As a frame of reference, the average U.S. cotton yield per hectare is 0.7 MT/HA. Besides Brazilian advantage in terms of cotton yields and land availability, the country has lower production costs related to most other cotton producing countries (Figure 3). The net cost of production in Brazil is 35 U.S. cents per pound (US$ 772 /MT), almost half the United States net cost of production of 68 U.S. cents per pound (US$ 1499 / MT) (Lima, 2002).

The recent changes in the Brazilian cotton sector, coupled with the enormous potential to expand cotton production, indicate that Brazil has the potential to become a powerful competitor to U.S. cotton in international export markets. Given the high yields, abundant acreage, and favorable growing conditions of the new region, it is likely that future cotton production increases will emanate from the new region. Therefore it is important to know the response of cotton acreage allocation to future increases in agricultural land in the new region, as well as, the impact that own and competing crops prices have on the acreage allocation decision to ascertain the future potential of Brazil as an important competitor in the cotton exports markets and formulate effective policy analysis, forecasting and appropriate strategic planning.

The objective of this study is to statistically estimate the cotton supply response in Brazil's emerging region, defined by the states of Mato Grosso and Goais, taking into account anticipated future increases in land availability, and the relative gross profitability of the major competing field crops (soybeans, corn, rice and cotton) grown in the new region. Scale elasticities, and own and cross price elasticities will be derived from an econometric model that estimates the acreage allocation equations within a supply systems framework. The scale elasticity provides a statistical estimate for the percentage change in cotton acreage that would result from a 1% percentage change in total agricultural area devoted to field crops. The calculated scale elasticity, own and cross price elasticities for cotton production in the emerging region are used to estimate the increase in Brazil's cotton production for the next 10 years, and compare its growth rate with Texas Tech University's projections for world wide cotton production growth to assess the impact that anticipated increases in Brazilian production are likely to have on the international export market.

Methods and Procedures

Bettendorf and Blomme (1994) and Barten and Vanloot (1996) developed an econometric model to estimate acreage response elasticities within a supply system framework that incorporates a total acreage constraint, allowing the calculation of acreage scale elasticities, defined as the response of a particular crop to an increase in total agricultural land. The Bettendorf and Blomme (1994) and Barten and Vanloot (1996) models (BB-BV) assume the decision making process a farmer uses when determining how to allocate available crop acreage to each crop is similar to the investment decision an investor makes who diversifies the composition of his investment portfolio based on own and relative prices, individual risk preferences, and budget availability. Thus, the acreage allocation decision is a function of the total acreage constraint, expected returns, and risk of expected returns. Based on these behavioral assumptions, BB and BV develop a linear acreage allocation system. These authors show that scale elasticities, and own and cross price elasticities can be readily derived from their acreage allocation system. The BB and BV model was specified as a one-region first-order differential time series allocation model.

Holt (1999) subsequently developed a variation of the BB-BV model, termed the "Linear Approximate Acreage Allocation Model". Holt explicitly notes that there are cases when the first-order differential acreage allocation model proposed by BB-BV is neither practical nor feasible; particularly, when only cross sectional or panel data with few time series observations are available. Given that only 14 time series observations on each of the 4 crops was available for the two dominant cotton producing states in the emerging cotton region, this study adopts Holt's empirical specification.

Acreage, yield and price data was collectively obtained from IBGE, the Brazilian Research Institute, and FGVDADOS, a privately owned Brazilian database service. The cotton production, yield, and producer price data used in this analysis is for seed cotton as opposed to lint cotton. A conversion factor of 0.35 was estimated from a 14-year Brazilian time series data set for lint yield per pound of processed bulk cotton.

A systems approach was used estimate the acreage allocation model for four crops consisting of: cotton (i=1), soybeans (i=2), corn (i=3) and rice (i=4). Between 1990 and 2003, the average share for cotton acreage in the new region was 3.69%, and the average shares for soybeans, corn and rice were 59.71%, 24.65% and 11.91% respectively. Although other crops are produced within the region, the statistical model only includes those crops that directly compete with cotton. Wheat was excluded because it represents only a small percentage of total acreage in the new region and does not compete with cotton acreage. Other activities such as food crop, pasture and ranching also do not directly affect cotton production decisions in a given year.

In any given year, the share of acreage allocated to a given crop is a function of the total acreage dedicated to the four crops and own and competing crop gross revenues. The dependent variable is the share of available acreage devoted to crop i in region k in year t (V_{ikt}). By construction, the total quantity of agricultural land that can be allocated to the four competing crops in a given year and region (A_{kt}) is equal to the sum of the acreage allocated to the each of the four crops in a given year and region (a_{ikt}). This relationship is shown in equation (1):

$$A_{kt} = \sum_{i=1}^{4} a_{ikt} \tag{1}$$

Where A_{kt} is total land available in state k in year t and a_{ikt} is land allocated to crop i, in state k, and year t. The crop acreage share for crop i in state k in year t (V_{ikt}), is derived by dividing the quantity of acreage allocated to each crop by total available acreage in the given state and year and is calculated using equation (2):

$$V_{ikt} = a_{ikt} / A_{kt} \tag{2}$$

Expected gross revenue per hectare (GR) for each crop in a given year, is used to explain the share of acreage allocation to each crop in that year. Net revenue per hectare, the difference between gross revenue and costs, is the preferred explanatory variable but state level cost data was not available. If we assume that crop production cost does not vary significantly over time, then expected crop gross revenue can be used as a proxy for expected crop net revenue. We assume the producer bases the acreage allocation decision on prior year's yields and expected market price. Expected per hectare gross revenue in year t for crop i in region k (GR_{ikt}) was calculated using equation (3):

$$GR_{ikt} = P_{ikt} * (Y_{i,k,t-1}) \tag{3}$$

Where P_{ikt} is the average monthly price received by farmers, for crop i in region k in marketing year t (MY_t), measured in Brazilian Reais ($R) per metric ton (MT). To be consistent with our assumptions concerning producer behavior, MY_t was defined as beginning in September of year t-1 and ending in August of year t, which is the month prior to the time when the acreage allocation decision is made in year t. $Y_{i,k,t-1}$ is average per hectare yield for crop i planted in state k in the prior year.

Using the constructed variables presented in equations (1) to (3), the acreage allocation system was estimated using the Non-Linear Seemingly Unrelated Regression (SUR) procedure provided by the SHAZAM Econometric Software package (Version 9). The four share crop equation allocation system was estimated as:

$$V_{ikt} = B_i + \sum_{j=1}^{4} S_{ij}\, GR_{jt} + C_{il} D_l + U_{ikt} \tag{4}$$

where B_i and S_{ij} and C_{il} are the coefficient parameters to be estimated in each share equation. In the *i*th share equation the B_i parameter represents the *average scale effect* in the reference state (Goais), and measures how much more (less) acreage will be planted to the *i*th crop if total land availability increases. The S_{ij} parameters measure how the share of acreage allocated to a specific crop i responds to change in its own price (i=j) and changes in other crop prices (i≠j). The C_{il} parameter in each share equation adjusts for potential differences in the scale effect between the two states used in the pooled data estimation procedure. The variable D_l is a dummy variable that has the value of 1 if the state is Mato Grasso and a value of 0 if the state is Goais. The term U_{ikt} is the random error term with mean zero. The theoretical restrictions of adding up, homogeneity, and symmetry were imposed on the estimated model. The imposed restrictions used in equations (4) are defined as $\sum_i B_i = 1$, $\sum_i S_{ij} = 0$, and $\sum_i C_{i1} = 0$ (adding up); $\sum_j S_{ij} = 0$ (homogeneity), and $S_{ij} = S_{ji}$ (symmetry). Because the covariance matrix associated with the error terms in equation (4) will be singular, an equation must be deleted in estimation (Barten, 1969). Accordingly, the rice equation was dropped in estimation. Economic theory suggests that S_{ii} parameter should be positive implying that acres planted to crop i will increase as the expected return to crop i increases. Conversely, S_{ij} ($i \neq j$) is expected to be negative as acreage allocated to crop i is likely to decrease if crop j return increases.

The coefficients of the estimated model can be transformed into scale elasticities, and own and cross-price elasticities for purposes of estimating the percentage increase (decrease) in acreage allocated to each crop. The scale elasticity, η_i, estimates the percentage increase or decrease in acreage devoted to crop i for a 1% increase available crop acres. As usual the own price and cross price elasticities, ε_{ij}, respectively measure the percentage change in acreage allocated to specific crop i for a 1% change in the crop i gross revenue, and the percentage change in acreage allocated to crop i for a 1% change in the price of crop j. Equations (5) and (6) present the elasticity calculation used in this analysis.

$$(5)\ \varepsilon_{ij} = (\partial a_i / \partial P_j) * (P_j / a_i) = S_{ij} / V_i \qquad \text{(Price elasticities)}$$

$$(6)\ \eta_i = (\partial a_i / \partial A_k) * (A_k / a_i) = B_{ij} / V_i \qquad \text{(Scale elasticities)}$$

Results

Parameter estimates, multiplied by 100, are reported in Table 1. 14 of the 24 parameter coefficient are statistically significant at the $\alpha = 0.05$ level. Of special relevance to this analysis is that the scale effect coefficients for all crops, B_i, were statistically significant at the $\alpha = 0.01$ level, or higher. Moreover the statistical significance of three of the four fixed effect parameter, C_{i1}, implies significant differences in the scale effect parameter for each crop between states, except for cotton. Thus the cotton scale effect is similar in both states. Not unexpectedly, soybeans, has the largest scale effect in both states. This is attributable to the fact that the Brazilian government has been actively encouraging soybean production within the Cerrado Savanna region for nearly three decades (Scneph, et. al.). These results indicate that as land increases in the emerging region, the response of acreage devoted to cotton is less dynamic than the response of all the other crops, meaning a high competition of cotton for land resources. The R^2 for cotton, soybeans, corn, and rice equations is 40%, 88%, 84%, and 64% respectively.

Focusing on the cotton allocation equation, the parameters for the scale effect and the own price and cross-price coefficient for corn are statistically significant but the cross-price coefficients for soybeans and rice are not, suggesting that cotton acreage significantly responds to changes in own gross revenue and corn gross revenues but does not directly compete with soybeans and rice for available acreage. Calculated scale, own price, and cross-price elasticities are reported in Table 2 with their associated t-values. The estimated cotton scale elasticity is 0.61 for Mato Grosso, and 0.75 for Goais indicating that a 10% increase in land devoted to field crops in the Mato Grosso state would result in a 6.1% increase in area devoted to cotton in that state. Similarly, a 10% increase in land devoted to field crops in Goais state, would increase cotton acreage by 7.5%. The own cotton price elasticity is 0.41, meaning that a 10% increase in cotton price would cause farmers to increase cotton acreage by 4.1% and the corn price elasticity of -0.3053 indicates that a 10% decrease in corn price would result in a 3% increase in cotton acreage.

Statistical projections of cotton production in the states of Mato Grosso and Goais were estimated for the 2003-2013 period as the product of the corresponding forecasts for cotton acreage and yields. The cotton acreage projections were derived using the annual average historic growth rate of acreage collectively allocated to the four dominant crops in the new region between 1990 and 2003, in combination with the estimated cotton scale elasticity to allocate the share of the increased acreage allocated to cotton production over time. Subsequently, cotton yields were projected under two different scenarios. The first scenario assumes that cotton yields increase at their historical rate in the projected period, and the second scenario assumes that cotton yields remain constant at the 2000-2003 average yield level. The forecasted acreage and yield values are subsequently used to forecast total production under each yield growth scenario.

The forecasted values for Brazil's future cotton acreages, yields and production levels are shown in figures 5, 6, and 7 respectively using an index measure with year 2003 assigned an index value of 1. In each figure, the cotton acreage, yield and production growth rates for Brazil's new region are compared to world's projected growth rate in order to assess the likelihood of Brazil becoming a major cotton exporter in the near future.

The acreage index comparison reveal that acreage allocated to cotton in Brazil's new region will grow at a slower rate than the world cotton acreage increase between 2003 and 2008, but from 2009 to 2013, Brazil's cotton acreage growth rate will exceed the world's (Figure 5). However, a comparison of yield projections (Figure 6), reveal that yield growth will be more rapid in Brazil than in the world over the next ten years due to superior agronomic and climatic factors. Thus, Brazil's total output in the new region is likely to exceed the world's cotton production growth rate if Brazilian yields increase at their historical trend and have a growth rate similar to the world if yields rate remains fixed at current levels (Figure 7).

Conclusions

Brazilian potential to significantly increase cotton production and exports in the medium-long term is enormous. Brazil's extensive uncultivated land availability, water resources, ideal climatic and agronomic conditions, supreme cotton yields and low net costs of production gives the country a superlative advantage. However, it is important to note that the utilization of that potential will depend on various crucial factors, such as cotton future profitability and the ability of cotton to out compete both corn and soybeans for the acreage in the future. Another critical factor will be the role government plays in facilitating private efforts to promote a massive expansion at Brazil's cotton production and exports (the Brazilian government has already shown a willingness to help soybean producers in the region).

Assuming that Brazilian cotton production will continue to concentrate in this new region, the future potential of Brazilian cotton production and exports will be determined among other things by Brazil's cotton yields growth rate, the rate to which additional land is incorporated to field crops production in the area, future behavior of cotton and competing crop prices and the capacity of the government to impose the proper incentive policies as well as to satisfactorily increase and/or improve the appropriate infrastructure.

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Table 1. Estimated Acreage Allocation Parameters.

Parameter	Estimate	t-Ratio
B_1	2.753	5.026
B_2	45.603	28.306
B_3	35.868	21.802
B_4	15.776	10.971
S_{11}	0.002	3.005
S_{12}	0.003	1.575
S_{13}	-0.003	-2.251
S_{14}	-0.001	-0.715
S_{21}	0.003	1.575
S_{22}	0.026	2.884
S_{23}	0.009	1.587
S_{24}	-0.038	-4.609
S_{31}	-0.003	-2.251
S_{32}	0.009	1.587
S_{33}	0.000	-0.070
S_{34}	-0.005	-1.095
S_{41}	-0.001	-0.715
S_{42}	-0.038	-4.609
S_{43}	-0.005	-1.095
S_{44}	0.044	5.334
C_{11}	-0.483	-0.726
C_{21}	18.116	10.058
C_{31}	-20.847	-9.824
C_{41}	3.216	16.761

Table 2. Estimated Scale, Own-price and Cross-price Elasticities.*

	Estimate		t-Ratio	
	MG	G	MG	G
η_1	0.614	0.745	4.403	5.025
η_2	1.066	0.763	47.095	28.305
η_3	0.609	1.454	9.499	21.801
η_4	1.591	1.322	16.761	10.97
ε_{11}	0.414		3.005	
ε_{12}	0.301		1.574	
ε_{13}	-0.305		-2.251	
ε_{14}	-0.089		-0.715	
ε_{21}	0.038		1.574	
ε_{22}	0.172		2.883	
ε_{23}	0.051		1.587	
ε_{24}	-0.177		-4.609	
ε_{31}	-0.115		-2.251	
ε_{32}	0.152		1.587	
ε_{33}	-0.005		-0.069	
ε_{34}	-0.062		-1.095	
ε_{41}	-0.082		-0.715	
ε_{42}	-1.269		-4.609	
ε_{43}	-0.15		-1.095	
ε_{44}	1.045		5.333	

*The elasticities were calculated at regional mean share and mean gross revenue.

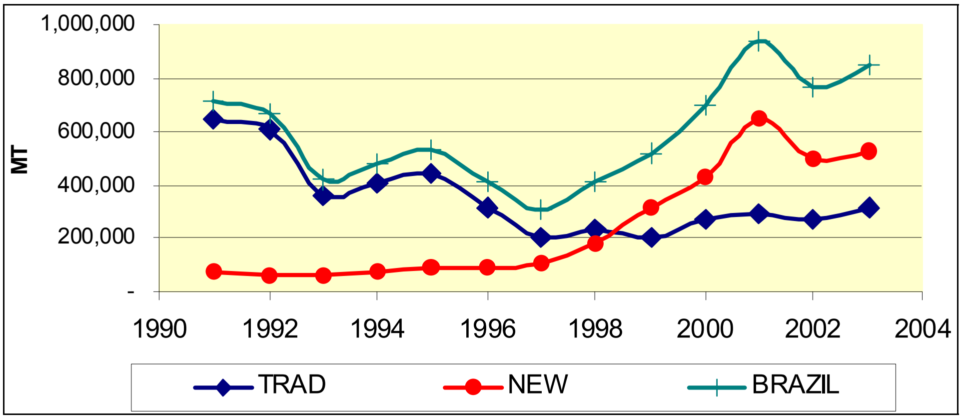

Figure 1. Brazil Cotton Production.

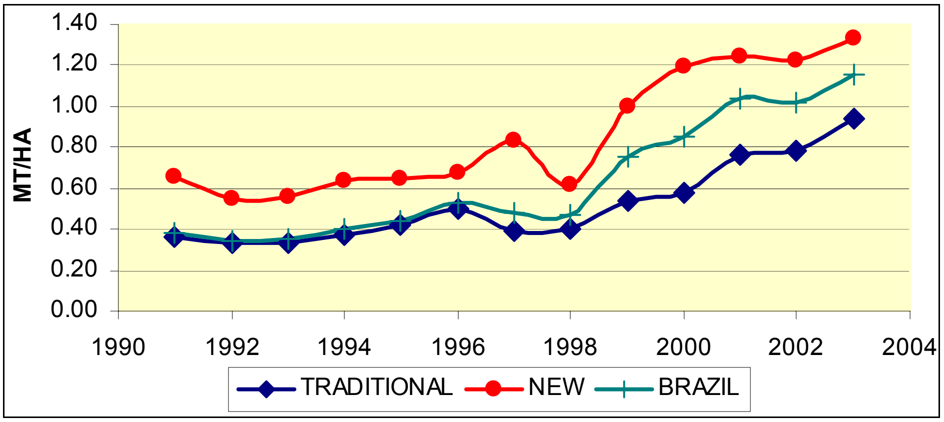

Figure 2. Brazil Lint Yields by Region.

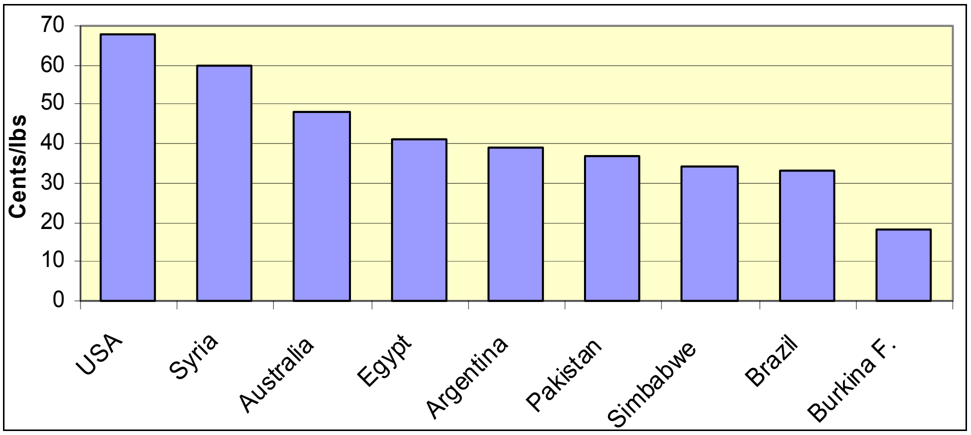

Figure 3. Net Cost of Production (Selected Countries). Source: Lima, 2002.

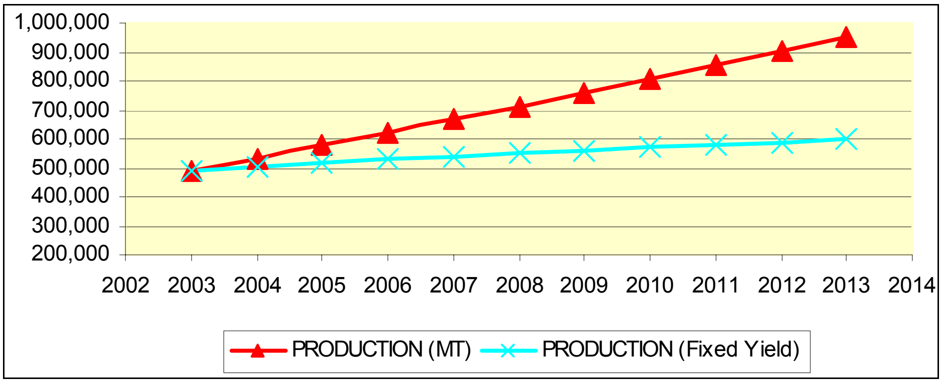

Figure 4. Brazil's New Region Cotton Production Projections.

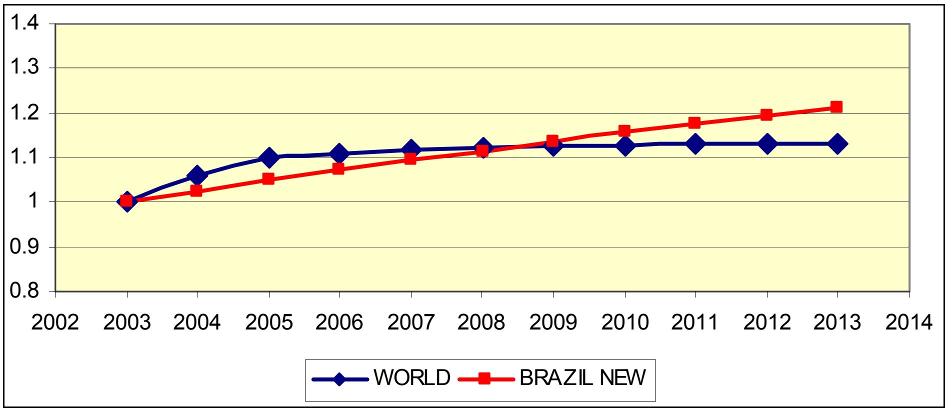

Figure 5. Cotton Area Indices (Base = 2003).

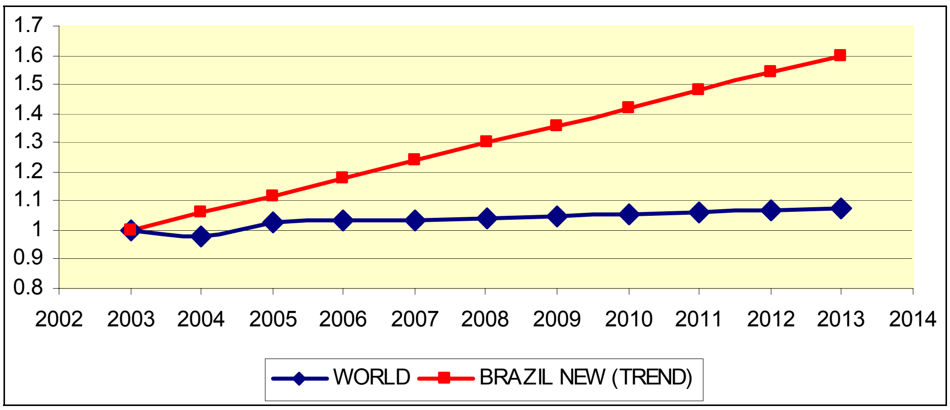

Figure 6. Cotton Yield Indices (Base = 2003).

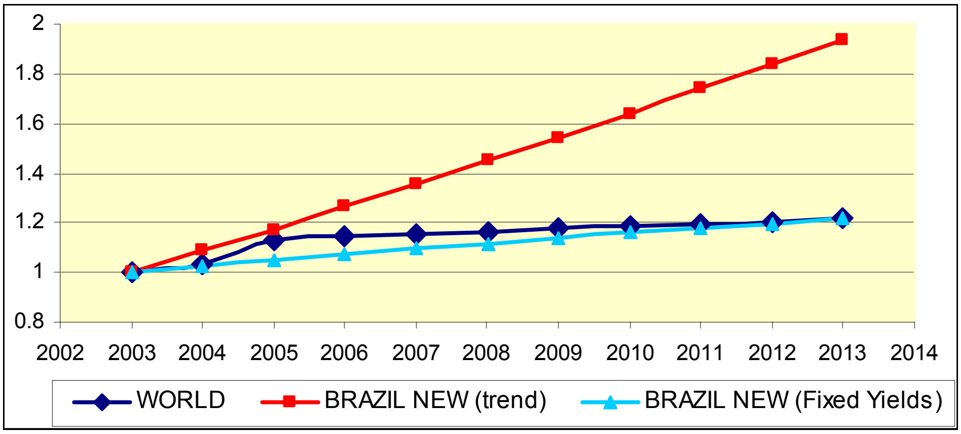

Figure 7. Cotton Production Indices (Base = 2003).