FORECASTING MODEL FOR THE PRODUCTION AND CONSUMPTION OF COTTON FIBER VERSUS POLYESTER

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ABSTRACT

With the expansion of agriculture in the Brazilian cerrado, Mato Grosso State has consolidated as the largest producer of cotton in Brazil since 1997. In 2013, 1.2 million tons of fiber cotton was produced in Brazil and Mato Grosso was responsible for 53% of this volume. Along with this, the economic changes in the textile industry caused changes in major cotton producing regions, and also in the consumption of the commodity in the Brazilian domestic market. Since then, producers oscillate acreage of the crop depending on market conditions. Therefore, it is understood that it is necessary to consider how the demand of the cotton by the domestic textile industry in the coming years and what would be the potential for expansion of the Brazilian production of the cotton. Moreover, the domestic textile industry, the main driver of consumption of cotton in Brazil has a range of raw materials for the manufacture of yarns, among them synthetic fibers, which has gained ground in the composition of textile products, threatening the growth of consumption cotton. Polyester is the main textile fiber substitute for cotton, increasing the share of total fiber consumed in Brazilian wirings. In 1970, the Brazilian Textile Industry Association (ABIT) estimated that the participation of all polyester fibers consumed by industry was 20%, while cotton accounted for the majority, 67%. In 2012, cotton lost space for man-made fibers, leaving 53% of total consumption, while the polyester increased to 27%. To steer the producers and the demand of natural fiber, the objective was to find a model to forecast planted area and yield of cotton in major producing States, and together project the demand of cotton and polyester in the Brazilian domestic market. With this, you can estimate what the growth potential of the market for the cotton in Brazil, to estimate the excess production of the fiber, which possibly should be exported, contributing to a positive balance of trade.

KEY WORDS

Cotton, polyester, demand, supply, forecasting

INTRODUCTION

Most of the cotton production in Brazil was in the Southeast and Northeast in the early 90s according to the National Supply Company (Conab) and during this period the production of cotton was carried out by small and medium producers. After the crisis of the productive sector, there was a displacement from cotton production to clenched and recovery of domestic production, which is considered by Kouri and Santos (2007), as part of the productive process redesign and management, with the aim of modernizing the activity and increased competitiveness, imposed by competition with imported raw material after the trade liberalization of the early 90's.

With the expansion of agriculture in the Brazilian cerrado, Mato Grosso State has consolidated as the largest producer of raw cotton in Brazil since 1997 (Conab). By 2013 1.2 million tons of raw cotton was produced in Brazil and Mato Grosso was responsible for 53% of this volume. Other Brazilian states also gained ground with the production of commodity as Bahia, which from 2000 became the 2nd state in production, and, Goiás and Mato Grosso do Sul follow behind in the rankings. Another highlighted region is the Mapito (Maranhão, Piauí, Tocantins), which are advancing in agriculture, also betting on cotton.

Cotton production began to contribute from the year 2000 to a positive trade balance of Brazil according to the Ministry of Agriculture, Livestock and Supply (MAPA), as the country started to supply the need of the domestic market and export cotton other countries. In 2012/13 crop was consolidated as the third largest exporter of cotton (USDA).

Along with this, the economic changes in the textile industry caused changes in major cotton producing regions, and also in the consumption of the commodity in the Brazilian domestic market. Since then, producers oscillate acreage of the crop depending on market conditions.

Therefore, it is understood that it is necessary to consider how the demand of the plume by the domestic textile industry in the coming years and what would be the potential for expansion of the Brazilian production of the plume. Moreover, the domestic textile industry, the main driver of consumption of cotton in Brazil has a range of raw materials for the manufacture of yarns, among them synthetic fibers, which has gained ground in the composition of textile products, threatening the growth of consumption cotton.

Polyester is the main textile fiber substitute for cotton, increasing the share of total fiber consumed in Brazilian wirings. In 1970, the Brazilian Textile Industry Association (ABIT) estimated that the participation of all polyester fibers consumed by industry was 20%, while cotton accounted for the majority, 67%. In 2012, cotton lost space for synthetic fibers, leaving 53% of total consumption, while the polyester increased to 27%. However the consumption of cotton grown in the last ten years 21.8%, while consumption of polyester, synthetic fiber most consumed by the textile industry grew 29.4%, revealing that synthetic fibers have gained competitiveness in the period.

To steer the producers and the demand of natural fiber, the objective was to find a model to forecast planted area and yield of cotton in major producing States, and together project the demand of cotton and polyester in the Brazilian domestic market. With this, you can estimate what the growth potential of the market for the cotton in Brazil, to estimate the excess production of the fiber, which possibly should be exported, contributing to a positive balance of trade.

METHODOLOGY

Demand forecasting is a technique that uses past to predict or forecast future values of data. Play an important role in establishing control policies for the inventory system, demand machines or materials, sequencing of jobs and demand for machinery and personnel.

Its function is to play a role in several areas in the management of organizations, such as the financial sector (in planning resource requirements), in the area of human resources (planning of changes in the level of the labor force) and the area of industrial (planning of raw materials). These forecasts are also essential in the operation of various aspects of production management, such as inventory management and development of aggregate production plans, the demand for raw materials. Demand forecasts are developed using quantitative methods, qualitative or combinations of both. Quantitative methods, known methods of forecasting, which is the basic unit of time in which the predictions are made, are based on time-series analysis (data describing the demand assessment over time). Qualitative methods used when historical data is scarce or non-existent, based on expert opinion, being vulnerable to trends that may compromise the reliability of results and qualitative methods have historically been the most used in predicting demand (Mentzer & Cox, 1984).

Such methods usually show a low degree of precision, nevertheless still widely used in businesses, even with the broadcast of the most advanced methods of forecasting, driven by advances in processing power and storage of computer data (Sanders & MalIrodt, 1994).

The use of qualitative methods, which seeks the consensus of opinion of a group of experts, seems to be related to the fact that the predictions generated by them meet the demand targets set by firms. A little practical reasons these predictions, on the other hand, can be explained in large part to poor precision offered by qualitative methods. (Fogliatto & Pellegrini, 2001).

The qualitative technique uses historical default data to extrapolate future behavior, and uses basically two techniques, and time series analysis and causal (or structural) models. This work was performed quantitative technique historic time series, and the random pattern with trend demand but without seasonal elements.

The demand projection was made for the next ten years, from 2013 to 2023, and the variables considered in the model were the cotton acreage, cotton productivity, consumption of cotton and polyester in Brazil.

To find the production of cotton in Brazil, we surveyed the historical series of acreage and productivity since 1996 in 4 states / regions of Brazil the National Supply Company (Conab):

1. Mato Grosso
2. Bahia
3. Goiás e Mato Grosso do Sul
4. Maranhão, Piauí e Tocantins
5. Other brazilian States

In the State of Mato Grosso and Bahia, is designed to separate production from other producing areas due to large representation of those States in producing national cotton.

To perform demand forecasting, data consumption of cotton and polyester were collected by the domestic industry. Consumption of cotton fiber is registered Conab nationwide since 1970, and to standardize the time series along with the other variables, we used the time series since 1996. The same was done with the history of consumption of polyester in Brazil, the source being the ABIT.

With the time series, trend lines were determined for each variable. The choice of the trend line was based on the accuracy test following steps:

1. The first step was to create a line graph with the time series of each variable in Microsoft Excel;
2. After it was selected 75% of the initial values of the time series, hiding the 25% later.
3. We adopted the trend lines to find the hidden values, and see which trendline that found closest recorded values, so the variation of the recorded values and the values found at the trend line was given by the following equation:

$$\Delta\, v = \frac{(v_{ltn} - v_{vrn})}{v_{vrn}}$$

Where:
V = variation among the registered number and the number found in the trend line;
V_{ltn} = value found in the trendline;
V_{vrn} = value recorded in the time series.

4. Then the average of the changes was made:

$$\mu\,\Delta = \sum \Delta \; \frac{1}{number\ of\ values}$$

Where
$\mu\,\Delta$ = average variations of 25% of the hidden values.

5. Therefore R^2 divided by the average of the variations, to give the MAPE (accuracy meter)

$$Mape = R^2/\mu\Delta$$

6. The higher the MAPE, the greater the precision of the trend line. Thus it was possible to select the trend line by its MAPE indicator.

With Mape was possible to calculate the projected production for polyester and cotton from 2013 to 2023.

RESULTS

Projections of cotton production

A. Mato Grosso:

The results for the accuracy test for the area of Mato Grosso follow the trend lines are in the table below to cotton acreage.

Table1. Test accuracy for trend lines for planted area in Mato Grosso.

Trendline	Formula	Mape	R^2
Linear	y = 34,514x + 57,371	3,1	0,79466
Logarithmic	y = 190,21ln(x) - 26,029	3,9	0,82644
Polynomial	$y = -2{,}8722x^2 + 77{,}597x - 57{,}516$	3,5	0,8651
Potency	$y = 48{,}206x^{0{,}9326}$	3,3	0,89083
Exponential	$y = 79{,}882e^{0{,}1564x}$	0,8	0,73168

As seen in the table, the model that showed the best result was logarithmic, with MAPE of 3.9. Still, the result was low, since although the R^2 have shown a relatively high value, the accuracy when compared with last year's series was low. Therefore we chose to use the projection model an average between the logarithmic curve and the potency curve type.

As for projection analysis of cotton yield, the table below illustrates the result. As you can see, the polynomial trendline showed the highest MAPE, with results equal to 11.4.

Table 2: Models for forecasting the productivity

Trendline	Formula	Mape	R^2
Linear	y = 158,9x + 2004	3,1	0,7986
Logarithmic	y = 928,92ln(x) + 1524,2	7,5	0,93452
Polynomial	$y = -16{,}669x^2 + 408{,}94x + 1337{,}2$	11,4	0,91109
Potency	$y = 1655{,}8x^{0{,}3476}$	4,7	0,92059
Exponential	$y = 2016{,}5e^{0{,}0571x}$	1,8	0,72578

However, when projected for a period of ten years from polynomial curve tends to negative values, which makes it unsuitable for the model, as can be seen in Chart 2. Therefore, the line of the logarithmic trend was adopted, which still had one MAPE 7.5.

B. Bahia

The projected trend for the state of Bahia line presented results with medium-low Mape.

Table3. Test accuracy for trend lines for planted area in Bahia.

Trendline	Formula	Mape	R^2
Linear	y = 18,263x + 24,771	2,8	0,61222
Logarithmic	y = 73,07ln(x) + 30,263	1,2	0,33559
Polynomial	$y = 2{,}8876x^2 - 25{,}052x + 140{,}28$	1,4	0,80813
Potency	$y = 62{,}804x^{0{,}4146}$	0,6	0,21878
Exponential	$y = 57{,}08e^{0{,}1122x}$	1,9	0,46801

Although not the curve with the highest R^2, the linear trend line was the type that had the highest Mape, due to higher correlation with the data of harvests occurred between 2009 and 2013, which were retained for comparison of the model.

Just as occurred to estimate productivity of Mato Grosso, the trend line for productivity Bahia got greater Mape in polynomial line.

Table 4: Model accuracy of cotton yield of Bahia

Trendline	Formula	Mape	R^2
Linear	y = 283,89x + 350,11	1,8	0,82407
Logarithmic	y = 1541,4ln(x) - 294,25	4,9	0,83186
Polynomial	$y = -24{,}385x^2 + 649{,}67x - 625{,}3$	10,9	0,9019
Potency	$y = 354{,}51x^{0{,}9486}$	1,6	0,76829
Exponential	$y = 550{,}54e^{0{,}1689x}$	0,4	0,71128

In the same way when seen in the graph on the long-term period, this curve indicates values below zero, which makes it unsuitable. Thus, the logarithmic line was selected because it had the second highest MAPE result with 4.9.

C. Goiás and Mato Grosso do Sul

Together, the states of Goiás and Mato Grosso do Sul has shown declining trend in cotton planted over the past few years the area. But the relative fluctuations of the acreage of these states has been great, which impacted negatively on R^2 and also in Mape, as can be seen in Table 5.

Table 5. Testing accuracy for trend lines for planted area of Goiás and Mato Grosso do Sul

Trendline	Formula	Mape	R^2
Linear	y = -3,2022x + 168,36	0,4	0,11
Logarithmic	y = -10,25ln(x) + 162,78	0,1	0,04
Polynomial	$y = -0{,}9964x^2 + 11{,}744x + 128{,}5$	0,4	0,26
Potency	$y = 160{,}68x^{-0{,}078}$	0,2	0,05
Exponential	$y = 167{,}04e^{-0{,}024x}$	0,5	0,14

Even having a value of less than R^2 polynomial when evaluated Mape, the exponential best fit line presented for modeling.

Unlike the trend lines of the planted area, the results showed high productivity Mape, and the logarithmic power line and totaled more than 20 points, according to table 6.

Table 6: Model accuracy of cotton productivity of Goiás and Mato Grosso do Sul

Trendline	Formula	Mape	R^2
Linear	y = 160,49x + 1760	5,8	0,81614
Logarithmic	y = 827,58ln(x) + 1474,5	20,6	0,74311
Polynomial	$y = -2{,}4319x^2 + 196{,}97x + 1662{,}7$	8,2	0,81853
Potency	$y = 1649{,}9x^{0{,}3067}$	28,5	0,71012
Exponential	$y = 1854{,}4e^{0{,}058x}$	2,9	0,74178

As the power curve type had the greatest Mape, but showed the R^2 among the lowest evaluated for long-term projection was adopted the average of the results of these two lines.

D. Maranhão, Piauí and Tocantins

So called states of Mapito (Maranhão, Piauí and Tocantins), are the latest from the farm selected for evaluation, so were aggregated. In the table below you can see that the largest MAPE was observed for linear and logarithmic line, with a value of 3.2.

Table 7: Model accuracy for trend lines for planted Maranhão, Piauí and Tocantins area.

Trendline	Formula	Mape	R^2
Linear	$y = 2,0536x + 0,09$	3,2	0,81759
Logarithmic	$y = 16,945\ln(x) - 17,474$	3,2	0,83762
Polynomial	$y = -0,1211x^2 + 4,2334x - 8,5078$	2,8	0,83976
Potency	$y = 1,4872x^{1,1401}$	3,1	0,8298
Exponential	$y = 5,0565e^{0,1335x}$	2,1	0,75615

The indicators for the cotton yield projection of Maranhão, Piauí and Tocantins showed a high Mape for the line type potency trend with value of 13.9 as shown in Table 8.

Table 8: Model accuracy of cotton yield of Maranhão, Piauí and Tocantins

Trendline	Formula	Mape	R^2
Linear	$y = 295,74x + 53,086$	2,6	0,87792
Logarithmic	$y = 1170,4\ln(x) - 34,695$	5,7	0,69397
Polynomial	$y = 16,118x^2 + 102,33x + 472,15$	1,2	0,89826
Potency	$y = 470,8x^{0,7457}$	13,9	0,75686
Exponential	$y = 524,68e^{0,1797x}$	0,5	0,87071

It is evident that using the line type potency projection productivity for 2023 would point values close to 5500 kilos per hectare, far above the projection of the other producing states. Therefore, we adopted the mean value between the potency trendline type and logarithmic type, which had submitted the second largest Mape.

E. Other States

The sum of the productive area of the other producing states of Brazil indicate a decline in area planted. As the current values of the remaining acreage in Brazil is relatively low, relative variations are high and this adversely affects the accuracy of any model. Nevertheless, analysis of the MAPE indicated exponential trend line, as the most appropriate for the case.

Table 9: Model accuracy of cotton yield of the other states of Brazil.

Trendline	Formula	Mape	R^2
Linear	$y = -28,882x + 460,86$	0,6	0,81288
Logarithmic	$y = -157,2\ln(x) + 527,06$	0,6	0,82431
Polynomial	$y = 0,6611x^2 - 38,798x + 487,31$	1,2	0,81833
Potency	$y = 705,82x^{-0,683}$	0,4	0,66119
Exponential	$y = 595,72e^{-0,141x}$	1,5	0,8259

The exponential shape of the curve indicates a trend of reduced acreage, but does not indicate that cotton planting in these regions should end.

By analyzing the trend lines for productivity in other states of Brazil became apparent extremely high Mape for logarithmic type line, even having one of the lowest values of R^2.

Table 10: Model accuracy of cotton yield in other states

Trendline	Formula	Mape	R^2
Linear	$y = 199{,}32x + 1155{,}3$	4,1	0,91868
Logarithmic	$y = 1069\ln(x) + 726{,}66$	30,5	0,90489
Polynomial	$y = -9{,}7105x^2 + 344{,}98x + 766{,}9$	19,5	0,94659
Potency	$y = 1046{,}4x^{0{,}4818}$	8,1	0,92128
Exponential	$y = 1308{,}9e^{0{,}0857x}$	1,7	0,85219

Forecasts of industrial consumption of cotton and polyester in Brazil

The estimates of consumption of cotton were drawn with trendlines available, and the accuracy test could opt for Polynomial Trendline by presenting the greatest value in MAPE.

Table 11. Testing of accuracy to trend lines for the consumption of cotton.

Trendline	Formula	Mape	R^2
Polynominal	$y = -0{,}0531x^2 + 10{,}903x + 759{,}78$	7,50	0,54
Exponential	$y = 768{,}38e^{0{,}0111x}$	7,47	0,55
Linear	$y = 9{,}7335x + 764{,}26$	7,40	0,54
Logarithmic	$y = 68{,}201\ln(x) + 723{,}95$	6,70	0,46
Potency	$y = 732{,}73x^{0{,}0783}$	6,95	0,48

Thus, there is a slight trend of increasing demand of raw cotton by industries, as was to be expected. To forecast the consumption of polyester, the average of the results of the trend of potency type and the polynomial type line was used, since both had a value of Mape high.

Table 12. Testing of accuracy, the trend lines for the consumption of polyester.

Trendline	Formula	Mape	R^2
Polynominal	$y = -0{,}3612x^2 + 24{,}354x + 101{,}27$	21,9	0,96
Exponential	$y = 154{,}6e^{0{,}0582x}$	9,0	0,92
Linear	$y = 16{,}408x + 131{,}73$	15,9	0,95
Logarithmic	$y = 119{,}32\ln(x) + 54{,}385$	12,4	0,87
Potency	$y = 111{,}72x^{0{,}4467}$	19,0	0,94

Comparing with the curve of the industrial demand for cotton fiber, it is evident that the demand for polyester is expected to grow at a faster rate.

Forecasts to production surplus

With an estimated supply of raw cotton in the Brazilian domestic market and demand forecasting of raw cotton and polyester, it was possible to draw a scenario of supply and demand of cotton, assuming that the surplus production should be exported.

The time series used for the projections it is clear that Brazil needed to import cotton to meet its domestic demand by 2001. With the expansion of culture to the cerrado Brazil became self-sufficient and now has surplus production.

Among the challenges for the chain of cotton in Brazil is competitiveness with polyester, which should gain more space 10 years from now. In 2013, between the two fibers more consumed by domestic textile industry, cotton participates with 69% polyester and 31%, since the projection for 2023 is 67% and 33% respectively. This is because the growth of cotton consumption is lower than the forecast of cotton production, by 2023 the cotton consumption is expected to grow 8% to 1.0 million tonnes, compared to an increase of 18% polyester coming in 657 tons . In contrast external economic factors can reverse projection, such as fluctuations in the price of oil, which is the main raw material for the manufacture of polyester.

Table 13. Consolidated result forecasting.

Year	Cotton fiber consumption	Polyester fiber consumption	Production of cotton in Brazil	Production surplus
1992	742	135	-	-
1993	830	161	-	-
1994	837	179	-	-
1995	804	187	-	-
1996	829	187	437	-392
1997	799	230	326	-473
1998	783	224	464	-319
1999	807	278	636	-171
2000	885	315	839	-46
2001	865	305	1.070	205
2002	805	315	859	54
2003	800	343	943	143
2004	930	401	1.445	515
2005	900	362	1.450	550
2006	890	375	1.128	238
2007	1006	379	1.588	582
2008	1050	446	1.646	596
2009	949	404	1.241	293
2010	1015	456	1.197	182
2011	910	443	2.032	1122
2012	865	434	1.912	1047
2013	974	444	1.280	306
2014	982	453	2.011	1028
2015	991	462	2.097	1106
2016	999	471	2.185	1185
2017	1007	479	2.273	1266
2018	1015	487	2.363	1348
2019	1023	495	2.454	1431
2020	1031	503	2.546	1514
2021	1039	510	2.638	1599
2022	1047	518	2.732	1685
2023	1054	525	2.826	1772

Unit: thousands tons

CONCLUSION

- ✓ The area of cotton production is expected to grow in the states of Mato Grosso, Bahia, Maranhão, Piauí and Tocantins, following the trend of expansion in recent years;
- ✓ Area reduction must occur in the states of Goiás, Mato Grosso do Sul and the average of the other states of Brazil;
- ✓ Despite the downward trend of the area in some regions, productivity tends to grow in all regions of the country;
- ✓ Consumption feather by industry should continue to grow, but at a slow pace;
- ✓ The substitution of polyester for cotton should continue occurring, since the nylon tends to grow at a higher rate if purchased at the growth of the cotton.
- ✓ Despite the increased consumption of industry, the surplus production should continue to grow from just over 30% of consumption to more than 170% of consumption in 10 years;
- ✓ With the estimated surplus production, it is essential to encourage the development of national industry and at the same time improving access to international markets;

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