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SWOT AND QUANTILE REGRESSION ANALYSIS OF CHINA'S COTTON INDUSTRY ECONOMY IN THE COVID-19 PANDEMIC

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Abstract. In this paper, the authors do a SWOT analysis of the strengths and weaknesses, opportunities and challenges in China's cotton industry. According to the specific type and distribution of the data, we choose a conditional quantile regression model and convert the parameter estimation of the model into solving an optimization problem. Subsequently, we discuss the relationship between various production and sales factors and prices, and obtain point and interval estimates of model parameters. We enumerate positive and negative factors affecting prices for specific quantiles and analyze their trends. Finally, we summarize the current status of China's cotton industry economy and provide some suggestions for government departments.

1. Introduction

The Covid-19 pandemic crisis continues to threaten countries across the globe. In response, the government has imposed lockdown orders, causing businesses to close and individuals to shelter in place. There has been little reporting on how the pandemic has affected cotton, which is mostly used in manufacturing and relies on apparel and apparel sales as the main driver of demand. USDA data show that cotton prices and international trade are affected by these precautions. The impact of the pandemic is particularly evident when looking at U.S. cotton prices in the first half of 2020. Statista reports that in 2020 U.S. apparel and accessories sales were down 50% in March compared to February, 75% in April compared to March, and down 20.0% compared to the same period in 2019 . This phenomenon is not limited to the US, as EU clothing imports fell by around $4 billion as of April 2020. China is the world's leading cotton import market and a major exporter of rayon products. Data from the United Nations in 2020 shows that in 2018, China ranked first with nearly $10 billion in cotton imports, far exceeding other importing countries. In the same year, China exported nearly $74 billion in cotton, more than five times that of the next major exporter. Thus, China provides an ideal case for studying how the COVID-19 pandemic affects international cotton trade [16].

In the field of business marketing and strategy, SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis has been used by countless practitioners, marketing researchers for nearly a decade and is now a common and popular tool.

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Grouping internal and external factors in a business area is a common starting point for strategic planning, since it can be built quickly and can benefit from multiple fronts. SWOT establishes the required underlying variables for the analysis by listing favorable and unfavorable internal and external factors or conditions. Typically, internal strengths and weaknesses that are considered first include factors such as image, structure, capacity and efficiency, and resources. The second external opportunities and threats considered include customers, competitors, market trends, partners, new technologies, economic policies and market regulation. Helms and Nixon [5] provide a comprehensive and systematic summary of the important literature on SWOT analysis and propose avenues for future research. Interested readers are referred to this article and the literature therein.

Ervural et al. [4] pointed out that SWOT analysis is also applied in energy policy formulation, as they help the government to effectively manage and optimize the total amount of energy to meet current development requirements as well as future environmental protection plans. Existing literature shows that topics of increasing research interest involve energy planning, energy policy and energy politics, and most of them are oriented towards renewable energy that meets the requirements of reliable, clean and cheap [6], [17]. Due to the complexity and multifaceted nature of energy planning problems, Multi-Criteria Decision Analysis (MCDA) is the most commonly used alternative analysis technique. The Analytic Hierarchy Process (AHP), Analytical Network Process (ANP), Preference Ranking Organization Method for Enrichment of Evaluations (PROMEE), and Elimination and Choice Expressing the Reality (ECER) are the most commonly used tools in energy policy applications [19].

Researchers typically use ordinary least squares (OLS) regression to assess or adjust for the relationship between continuous independent variables and continuous dependent variables. The traditional linear regression model describes how the conditional distribution of the dependent variable is affected by the independent variable X, which describes the mean effect of the independent variable X on the dependent variable Y. In general, there is no single algebraic relationship that accurately describes how independent variables relate to continuous dependent variables [2]. If the random disturbance term in the model comes from a distribution with zero mean and homoscedasticity, then the least squares estimate of the regression coefficients is the best linear unbiased estimate (BLUE). If the further random disturbance term follows a normal distribution, then the least squares or maximum likelihood estimation of the regression coefficients is called Minimum Variance Unbiased Estimation (MVUE). However, in actual economic life, this assumption is often not satisfied. For example, the data has a peaked or thick-tailed distribution, and there is significant heteroscedasticity. At this time, the least squares estimation will no longer have the above excellent properties and low robustness [15].

In order to make up for the defects of OLS in regression analysis, Koenker and Bassett [11] proposed the idea of quantile regression in 1978. It regresses the independent variable X according to the conditional quantile of the dependent variable, thus obtaining the regression model under all quantiles. Therefore, compared with ordinary least squares regression, quantile regression can only describe the influence of the independent variable X on the local change of the dependent variable

Y, and can more accurately describe the effect of the independent variable X on the dependent variable Y. The range of variation and the effect of the shape of the conditional distribution. Quantile regression can capture the tail characteristics of the distribution. As the independent variables have different effects on the distribution of different dependent variables, such as when there is left or right skew, it can more comprehensively describe the characteristics of the distribution, so as to obtain a comprehensive analysis, and its quantile regression coefficient estimates are more robust than OLS regression coefficient estimates [3]. In recent years, the theory and methods of quantile regression have been developed very rapidly in various fields. Koenker and Hallock [12] gave an excellent review of the robustness of quantile regression, the relationship between variable heteroscedasticity and sample selection, and the development of quantile regression in multivariate analysis.

In this article, we collect data on cotton production and sales to study the future direction of China's cotton market. The rest of the article is organized as follows. In Section 2, we do a SWOT analysis of China's cotton industry economy from four aspects: strengths, weaknesses, opportunities and threats. In Section 3, we choose a conditional quantile regression model based on the specific type and distribution of the data. We highlight the mathematical principles of the model and translate the parameter estimation of the model into solving an optimization problem. The advantage of the model is that the objective function can represent multiple quantiles, breaking through the limitations of median estimation and ordinary least squares. The relationship between various production and sales factors (explanatory variables) and prices (response variables) is discussed in Section 4. We employ point estimation and interval estimation, respectively, to determine the parameters of the model. Quantile regression analysis at the endpoints of an interval has special significance. We enumerate positive and negative factors that affect prices and analyze their reasons and trends in a real-world context in detail. In Section 5, we summarize the current status of China's cotton industry in terms of planting production and sales regulation, and provide advice to government agencies.

2. SWOT analysis of Chinese cotton

Cotton affects international relations at different levels and is also an important strategic commodity. As one of the important raw materials of the textile industry, cotton occupies an important position in China's national economy. China is a major cotton producer and consumer in the world, ranking first in the world in terms of total output and unit output. China's cotton industry chain involves cotton processing, circulation, textile, printing and dyeing, clothing, export and other industries, and the market prospect is very broad. In this section, we will analyze the strength (S), weakness (W), opportunity (O) and threat (T) of Chinese cotton in detail (see Figure 1).

2.1. **Strength (S).** In China, the area suitable for planting cotton is vast. Cotton has strong growth adaptability, has the characteristics of drought resistance and waterlogging resistance, and has a wide range of growth. Since cotton likes mild and sunny weather and is more suitable for growing in loose and slightly alkaline

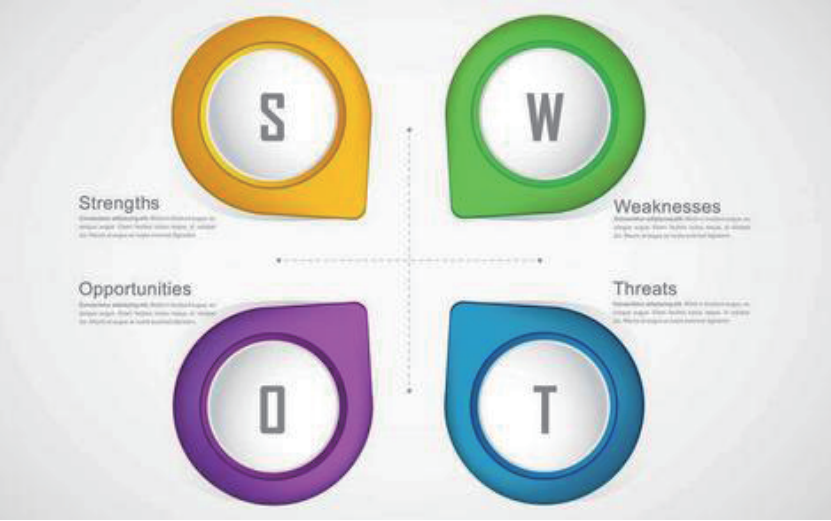


FIGURE 1. SWOT analysis

soil, there are many areas in the world that cannot meet the basic conditions for growing cotton. China's northwest, northeast and other regions have abundant land resources, long sunshine hours, good air dryness, and complete irrigation and farming facilities. Cotton grown in such a unique natural environment is of high quality, high yield and high sales.

The vigorous development of China's economy, both at the social level and at the technological level, has provided the impetus for the high-level development of the cotton industry. Especially with the rapid development of the field of biomedicine, people's industrial demand for cotton is increasing, and the quality requirements for cotton are also getting higher and higher. Although the economic cost of cotton cultivation is increasing year by year (see Figure 2), cotton production can be integrated, and large-scale batch cultivation can effectively control the cost increase within an acceptable range. Cotton products are labor-intensive products that require a large proportion of labor input. Abundant labor resources are precisely China's advantage, which makes China's cotton industry highly competitive.

China's increasing cultivation and planting technology makes China's cotton industry have great potential to develop into various types of high-quality cotton. On the one hand, after years of screening combinations, the proportion of good genes in Chinese cotton seeds has increased significantly. On the other hand, cotton picking and processing technology is at the leading level in the world. Many cotton varieties grown in China are rated as first-class products, and the export advantage of cotton processed products is obvious. It can be seen that China's cotton has a significant advantage in terms of production methods, cultivation types, product quality and export scale.

2.2. **Weakness (W).** Skilled workers engaged in cotton production-related jobs are scarce. The cultural level of the labor force in many regions of the country is relatively low, and generally they have not received or only received a small

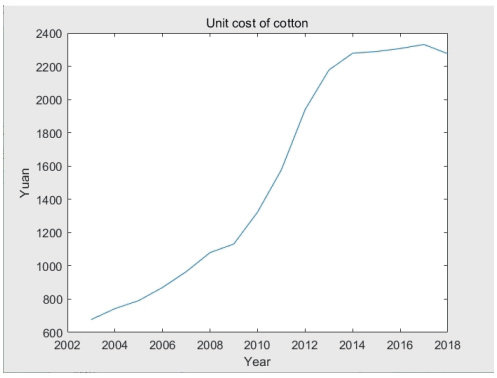


FIGURE 2. Unit cost of cotton from 2003 to 2018 (Unit: Yuan)

amount of vocational training. Although this phenomenon is changing, there is still a shortage of professionals in cotton cultivation, which will affect cotton production, reduce related benefits and increase costs.

China's infrastructure (including expressways, high-speed railways, etc.) is developing rapidly. However, some remote areas still have the problem of inconvenient transportation, which greatly affects the sales progress and sales price of cotton. Excessive price increases will reduce the competitiveness of cotton in the international market. If the price increase is too small, it will reduce the income brought by cotton planting, reduce the enthusiasm of cotton farmers, reduce the scale of cotton planting, and further affect the supply of cotton and its processed products.

The government's supervision of the cotton product processing industry is not enough, and the relevant punishment measures and policies must also be strengthened. High-quality cotton may be doped with inferior cotton, resulting in uneven quality of processed cotton products, lowering the quality of processed cotton products and reducing their market share. Another important factor affecting the sales of cotton processed products comes from industry competition. With the development of society and the advancement of science and technology, daily necessities such as quilts and cotton jackets have been replaced by down quilts and down jackets.

There are too many primary cotton products, and the industrial chain is too short. China's total cotton output ranks first in the world, but the output of cotton yarn and other processed products is not high, thus reducing the benefits of cotton processed products. In addition, the labor cost of upfront training in knowledge and skills is lower. Although it reduces the production cost to a certain extent, the production capacity and benefits still cannot match. There are many primary processing plants in many regions, the industrial chain is short, the income is low, and the market has not been fully developed.

Although the output of high-quality cotton is high, the types of high-quality cotton still need to be increased, and the proportion of low-quality cotton is still relatively high. The main reason for the current situation is that the planting conditions of high-quality and high-yield cotton are slightly higher, and the natural

environment in many areas is not suitable for its normal growth. If the conditions are artificially provided, the planting cost will be greatly increased, which will undoubtedly reduce the income and market competitiveness, and the harm will outweigh the benefit. Not only that, although the quality of Chinese cotton has been improving, the quality of Chinese cotton spinning products still does not exceed the quality of developed countries, especially in terms of mercerization and elasticity.

Disease and pest damage is still an important issue affecting cotton production and sustainable development. After years of "drug screening", many cotton pests have high drug resistance, and research on new deworming drugs is imminent. In addition, due to large-scale long-term planting, the accumulation of pathogens in the soil increases, which provides a source for cotton disease, aggravates the probability and degree of cotton disease, and seriously affects cotton yield and cost benefits.

2.3. **Opportunity (O).** The Chinese government has issued a number of policies to vigorously support the development of the cotton yarn textile industry, which will undoubtedly promote the vigorous development of the cotton industry. One may find the detailed national policies of the cotton yarn textile industry from 2016 to 2018 in Appendix A.

The development of emerging industries promotes the development of cotton industry. With the rise of emerging industries, the variety of cotton processing products has increased, and the variety of income has been rich, and the consumption of cotton has increased accordingly.

The trend of global economic integration has been formed. Due to the long-term influence of external economic and environmental factors such as the WTO, China's cotton products have entered the international market smoothly. This provides a good opportunity for the development of China's cotton industry.

The industrial structure has been adjusted, and the competitive pressure has been reduced. Many cotton farmers have looked away from cotton and turned to other products, such as pollution-free vegetables, flowers, and medicinal materials. These adjustments have helped reduce competition with the cotton industry, allowing cotton-growing regions to capture a higher share of the cotton market, increasing motivation and increasing yields.

2.4. **Threat (T).** The domestic cotton demand gap is relatively large, while the international cotton demand has basically reached a balance, so the imported cotton has a lower price. Some countries have implemented a high subsidy system for cotton, which widens the gap between domestic and foreign cotton prices and threatens the domestic cotton market even more. The annual import volume is far greater than the export volume, resulting in a low export competition rate of China's cotton textile products.

Due to the influence of human factors such as continuous cultivation and technological development, the natural environment has gradually deteriorated. The loss of soil nutrients, pH imbalance, and serious desertification of the land have restricted the development of the cotton industry, and cotton cultivation has been challenged.

The cotton industry has a weak foundation and a single variety of processed products, which makes the cotton industry more vulnerable to economic shocks.

In recent years, the unit profit of cotton fluctuated greatly, and the production enthusiasm of cotton farmers was unstable. Figure 3-4 show that cotton profit and prices vary widely, making farmers less confident about the market outlook.

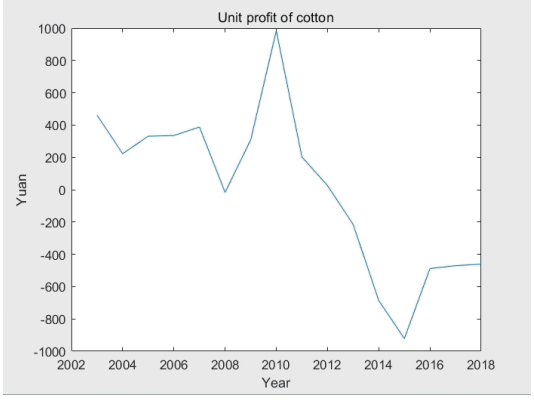


FIGURE 3. Unit profit of cotton from 2003 to 2018 (Unit: Yuan)

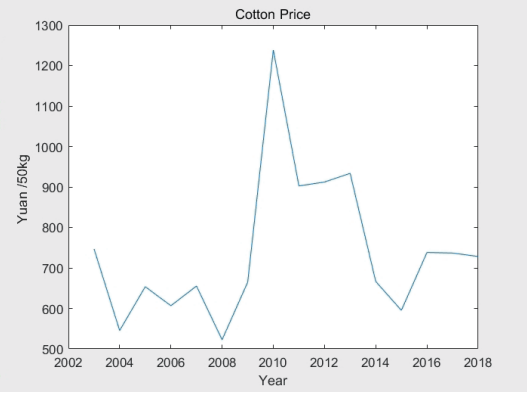


FIGURE 4. Cotton price from 2003 to 2018 (Unit: Yuan/50kg)

3. Quantile regression analysis of China's cotton industry

As we all know, any industrial economy will be constrained by many factors. On the one hand, OLS regression may unilaterally reflect the characteristics of some factors, while ignoring the characteristic information of other equally important factors. On the other hand, the essence of median regression is to provide a significant fractional proportion (in a probabilistic sense). For other quantiles, we can also obtain the nonlinear characteristics of the sample data. In particular, the endpoints of quantile intervals often have critical properties. Starting from this section, we study the quantile regression analysis of China's cotton industry economy.

3.1. **Variables and data.** In order to comprehensively analyze the fluctuation factors of the cotton market, we selected 12 factors (explanatory variables) that affect cotton prices (response variables), including total cotton production, cotton sown area, and export cotton amount, as shown in Table 1.

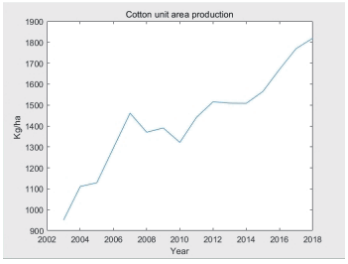
TABLE 1. Regression Related Variables and Description

Notation	Meaning	Description
Response variable y	Cotton price	Annual average price of cotton in China (yuan/50kg)
Explanatory variable x_1	Cotton unit output	Annual average unit yield of cotton in China (kg/ha)
Explanatory variable x_2	Total cotton production	Total annual production of cotton in China (thousand tons)
Explanatory variable x_3	Cotton planting area	Total annual cotton planting area in China (thousand hectares)
Explanatory variable x_4	Total cotton export value	Total annual export value of Chinese cotton (million US dollars)
Explanatory variable x_5	Total export weight of cotton	Total annual export weight of Chinese cotton (tons)
Explanatory variable x_6	Total cotton import value	Total annual import value of cotton in China (million US dollars)
Explanatory variable x_7	Total cotton import weight	Total annual import weight of Chinese cotton (tons)
Explanatory variable x_8	Consumer Price Index	The annual average consumption index of Chinese residents, 1978 is used as the base year, and the value is 100
Explanatory variable x_9	Resident consumption level	Annual average consumption level of Chinese residents (yuan)
Explanatory variable x_{10}	Residents' Clothing Consumption Index	The annual average consumption index of Chinese residents' clothing, the previous year is used as the base, and the value is 100
Explanatory variable x_{11}	Gross domestic product	China's annual GDP (100 million yuan)
Explanatory variable x_{12}	Textile Retail Price Index	The annual average retail price index of China's textiles, the previous year is used as the base, and the value is 100

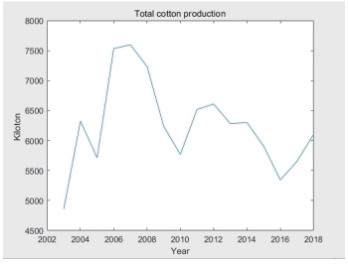
Statistics for 2003-2018 are from CEIC database (https://insights.ceicdata.com/https://insights.ceicdata.com/) and the National Bureau of Statistics of China (https://data.stats.gov.cn/https://data.stats.gov.cn/). Figure 4 shows cotton prices, while the line graph of each variable is as follows, and the original data is in the Appendix B.

It can be seen from the data distribution that each factor (explanatory variable) changes drastically with time, and the quantile regression method is suitable for analyzing this group of data.

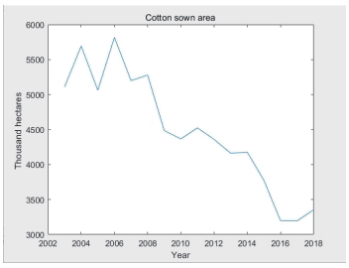
3.2. **Model principle.** Since Koenker and Bassett proposed the quantile regression model in 1978, the quantile regression theory has been gradually improved. The



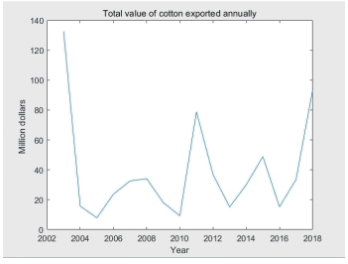
(a) Cotton unit area production



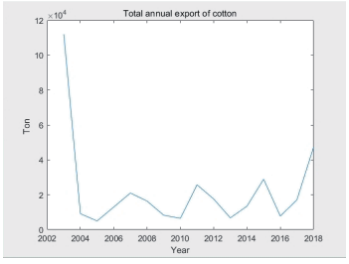
(b) Total cotton production



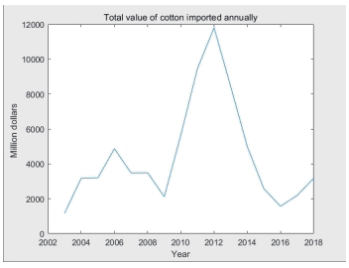
(c) Cotton swon area



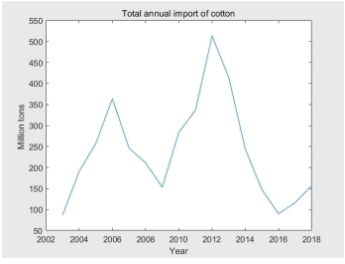
(d) Total value of cotton exported annually



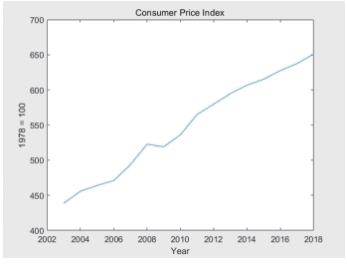
(e) Toal annual export of cotton



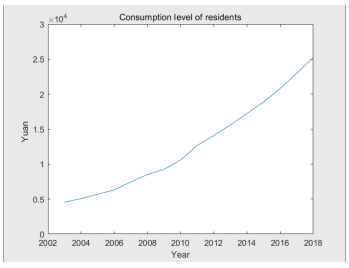
(f) Total value of cotton imported annually



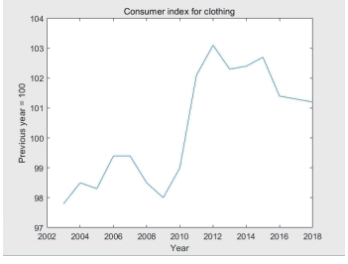
(g) Toal annual import of cotton



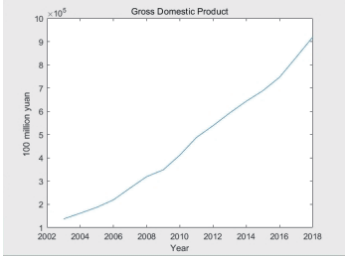
(h) Consumer Price Index



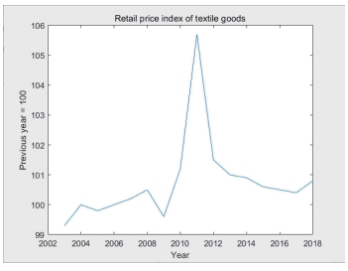
(i) Consumption level of residents



(j) Consumer Index for clothing



(k) Gross Domestic Product



(l) Retail price index of textile goods

classic monograph [10] in this field gives a complete description of the principle of the model.

Given a real random variable Y, its properties can be expressed by the distribution function (right continuous) of Y, i.e.

$$F(y) = P(Y \leqslant y). \tag{3.1}$$

For any $0 < \tau < 1$, the map

$$F^{-1}(\tau) = \inf\{y : F(y) \geqslant \tau\} \tag{3.2}$$

is called the τ-quantile function of the random variable Y.

Define the following loss function

$$\rho_\tau(u) = u(\tau - I(u < 0)) = \begin{cases} u(\tau - 1) & u < 0 \\ u\tau & u \geqslant 0 \end{cases}, \tag{3.3}$$

where $I(u < 0)$ is the indicative function, i.e. $u < 0, \quad I(u < 0) = 1$, while $u \geqslant 0, \quad I(u < 0) = 0$. Obviously, the loss function is a piecewise function. For convenience, the loss function can be written in the following form

$$\rho_\tau(u) = u(\tau - 1)I(u < 0) + u\tau I(u \geqslant 0). \tag{3.4}$$

The τ-quantile regression of Y is to find a ζ that minimizes the mathematical expectation $\mathrm{E}\left[\rho_\tau(Y - \zeta)\right]$. Taking mathematical expectation via Eq. (3.4), one yields

$$\mathrm{E}\left[\rho_\tau(Y - \zeta)\right] = (\tau - 1)\int_{-\infty}^{\zeta}(y - \zeta)dF(y) + \tau\int_{\zeta}^{+\infty}(y - \zeta)dF(y). \tag{3.5}$$

In order to find the minimum value $\min \mathrm{E}\left[\rho_\tau(Y - \zeta)\right]$, one takes the first-order partial derivative with respect to ζ in Eq. (3.5), and let the derivative equal to zero to get the equation satisfied by the equilibrium point

$$0 = (\tau - 1)\int_{-\infty}^{\zeta} -dF(y) + \tau\int_{\zeta}^{+\infty} -dF(y) = F(\zeta) - \tau. \tag{3.6}$$

Since the distribution function $0 \leqslant F \leqslant 1$ is a monotone non-decreasing function, for any $\tau \in (0, 1)$, there must be a certain interval of ζ that makes $\mathrm{E}\left[\rho_\tau(Y - \zeta)\right]$ take the minimum value. In particular, if the distribution function is strictly monotonically increasing and continuous, Eq. (3.6) has a unique solution $\zeta = Q(\tau) = F^{-1}(\tau)$.

As the empirical distribution function corresponding to the sample $\{y_k\}_{k=1}^m$

$$F_m(y) = \frac{1}{m}\sum_{k=1}^{m} I\{y_k \leqslant y\}$$

replaces the distribution function F, one has

$$\mathrm{E}\left[\rho_\tau(Y - \zeta)\right] = \int_{-\infty}^{\infty}\rho_\tau(y - \zeta)dF_m(y) = \frac{1}{m}\sum_{k=1}^{m}\rho_\tau(y_k - \zeta).$$

Therefore, finding the sample quantile is transformed into solving the following optimization problem

$$\min_{Q(\tau)\in\mathbf{R}}\sum_{k=1}^{m}\rho_\tau(y_k - Q(\tau)). \tag{3.7}$$

For a given sample $(X,Y)=\left\{\left(x_k^T,y_k\right)\right\}_{k=1}^m$, one considers the optimization problem corresponding to the conditional quantile

$$\min_{Q_Y(\tau|X)\in\mathbf{R}}\sum_{k=1}^m\rho_\tau(y_k-Q_Y(\tau|X)), \tag{3.8}$$

where $Q_Y(\tau|X)$ is the conditional quantile function, m is the sample size, n is the number of explanatory variables,

$$X=\begin{bmatrix}1 & x_{11} & \cdots & x_{1n}\\ 1 & x_{21} & \cdots & x_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ 1 & x_{m1} & \cdots & x_{mn}\end{bmatrix}_{m\times(n+1)}=\begin{bmatrix}x_1^T\\ x_2^T\\ \vdots\\ x_m^T\end{bmatrix},\qquad Y=\begin{bmatrix}y_1\\ y_2\\ \vdots\\ y_m\end{bmatrix}.$$

In particular, if the conditional quantile function is a linear function, then $Q_Y(\tau|X)=X\beta$, where $\beta=(\beta_0,\beta_1,\cdots,\beta_n)^T$, β_0 represents the intercept, β_j $(j=1,2,\cdots,n$) represent the regression parameters of the explanatory variables. At this point, problem (3.8) transforms into

$$\min_{\beta\in\mathbf{R}^n}\sum_{k=1}^m\rho_\tau(y_k-x_k^T\beta). \tag{3.9}$$

4. Quantile estimation of parameters

In this section, we estimate the parameters of the linear conditional quantile regression model (3.9). We give point estimates and interval estimates for each explanatory variable in subsections 4.1 and 4.2, respectively. In subsection 4.3, two typical quantiles at the endpoints of the interval are analyzed.

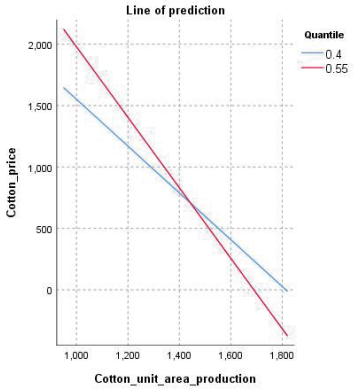
4.1. **Point estimation.** The main algorithms for solving parametric regression models include Simplex Method [1,8], Interior Point Method [7,20] and Smoothing Method [14]. SPSS 26 obtains the prediction line of the response variable with respect to each explanatory variable.

4.2. **Interval Estimation.** Confidence interval methods for regression quantile coefficients include Direct Estimation Method [11,13], Rank Score Method [9], Resampling method [18]. SPSS 26 produces a plot of interval estimates of the intercept and quantile regression coefficients for each explanatory variable, where the quantiles range from $[0.4,0.55]$.

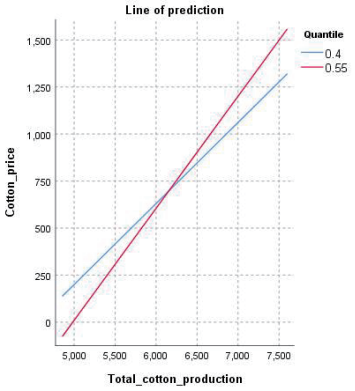
4.3. **Typical quantile characteristics.** In this subsection, we use SPSS 26 to analyze the endpoints of the quantile intervals.

The regression indicators for different quantiles are shown in Table 2.

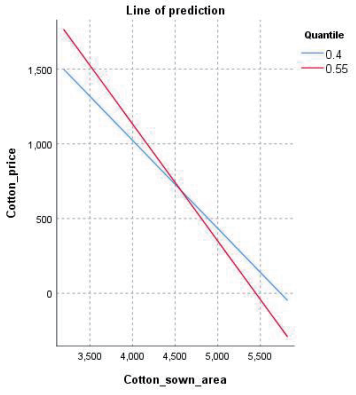
Table 2 illustrates that both the pseudo R-square and the mean absolute error (MAE) change as the quantile changes. The pseudo R-square is the degree to which the independent variables of the current model explain the variation of the dependent variable, indicating the goodness of fit. The closer its value is to 1, the better the fit of the model. MAE describes the average of the absolute value of the



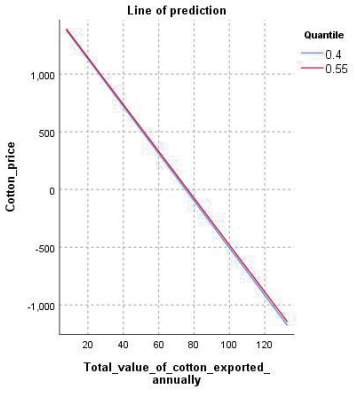
(m) Cotton unit area production



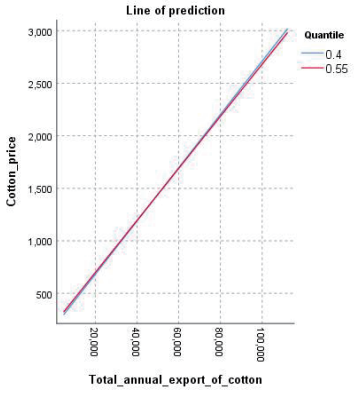
(n) Total cotton production



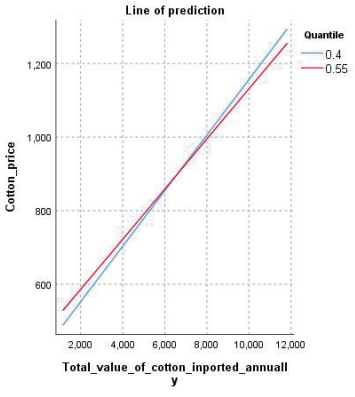
(o) Cotton swon area



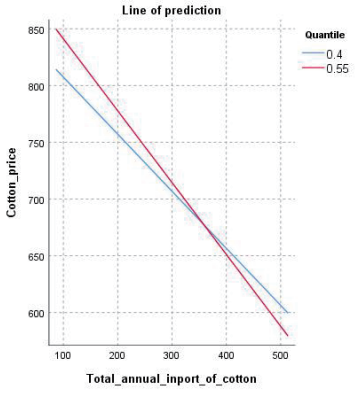
(p) Total value of cotton exported annually



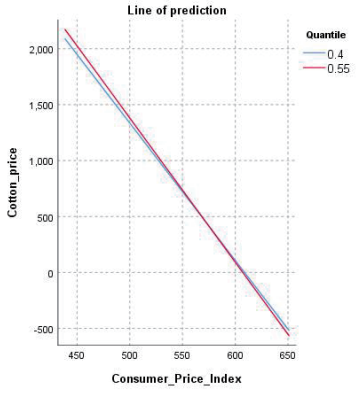
(q) Toal annual export of cotton



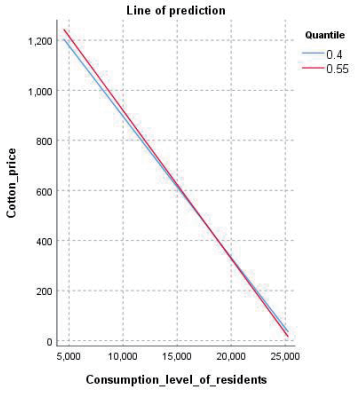
(r) Total value of cotton imported annually



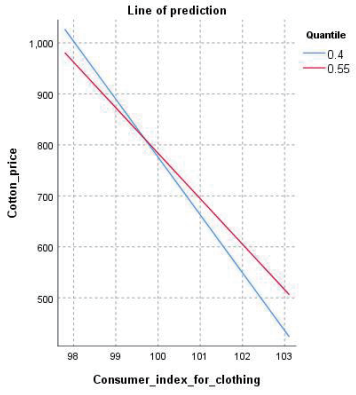
(s) Toal annual import of cotton



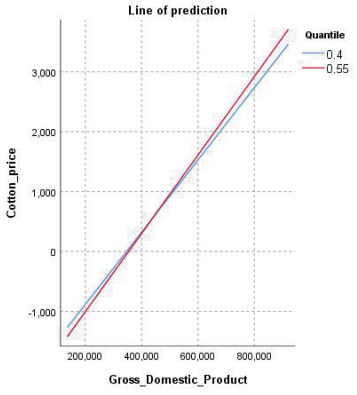
(t) Consumer Price Index



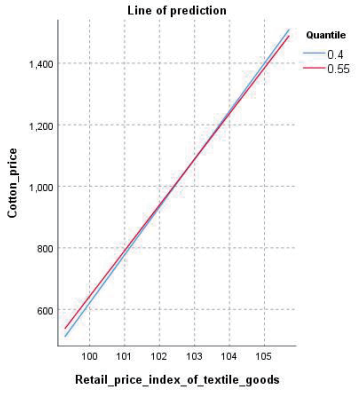
(u) Consumption level of residents



(v) Consumer Index for clothing



(w) Gross Domestic Product



(x) Retail price index of textile goods

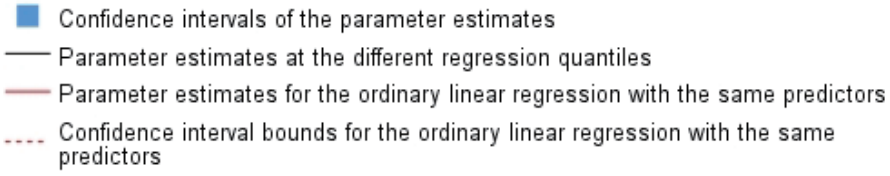


FIGURE 5. The specific meaning of the curve

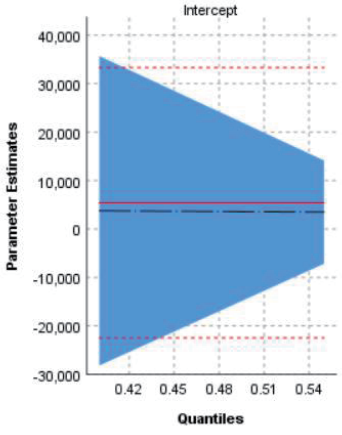


FIGURE 6. The specific meaning of the curve

TABLE 2. Model quality at different quartiles

	Model Quality	
Quantile	$\tau = 0.4$	$\tau = 0.55$
Pseudo-R-squared	0.886	0.907
Mean Absolute Error	13.2382	13.22

deviation of a single observation from the arithmetic mean, which can accurately reflect the size of the actual error. The smaller its value, the smaller the error.

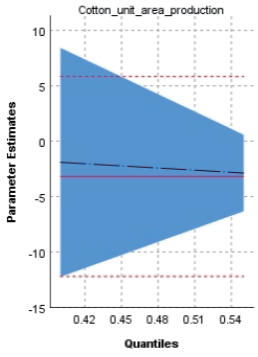
The regression parameters for quantile $\tau = 0.4$ are shown in Table 3.

As the quantile $\tau = 0.4$, Table 3 shows that the total export amount of cotton, the total export volume of cotton, and the retail price index of textiles have significant statistical significance at the 5% level.

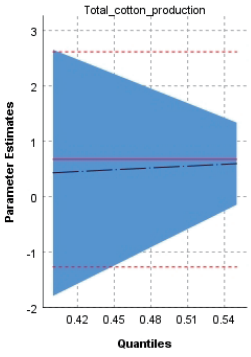
The regression parameters for quantile $\tau = 0.55$ are shown in Table 4.

As the quantile $\tau = 0.55$, Table 4 shows that the total export value of cotton, the total export volume of cotton, the clothing household consumption index, the household price consumption index and the textile retail price index have significant statistical significance at the 5% level.

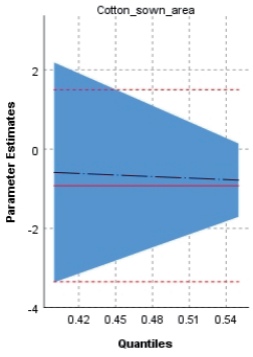
Table 5 compares the parameter estimates for the two groups of quantiles.



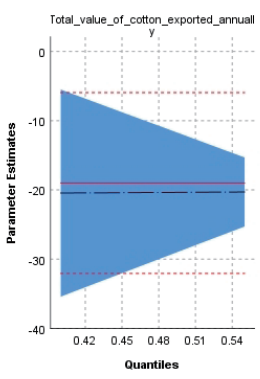
(a) Cotton unit area production



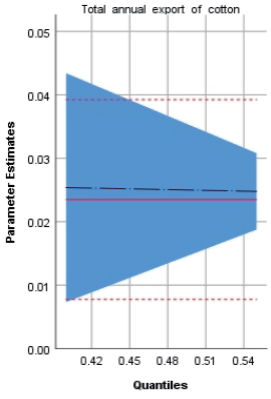
(b) Total cotton production



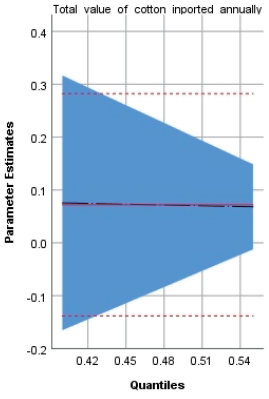
(c) Cotton swon area



(d) Total value of cotton exported annually



(e) Toal annual export of cotton

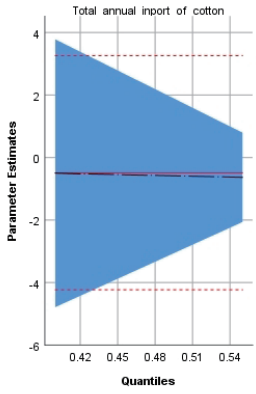


(f) Total value of cotton imported annually

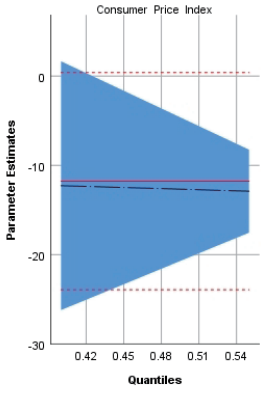
Table 5 shows that the selected factors (explaining variables) change with the quantile, indicating that the quantile model effectively reflects the impact of each factor on cotton prices. The total output of cotton, the amount of exported cotton, the amount of imported cotton, the gross domestic product and the retail price index of textiles have a positive impact on the price of cotton. The price index, household consumption level and clothing household consumption index have a negative impact on cotton prices, we will analyze them separately.

- Positive factors.

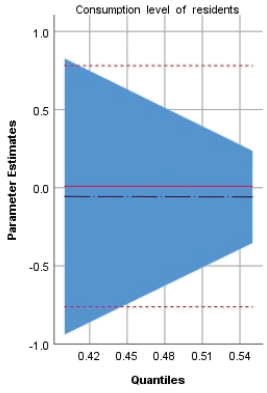
(1) Total cotton output: Under the condition that the demand remains stable, the increase in the total cotton output will reduce the sales price. However, sales will increase as the market widens, making the increase in demand



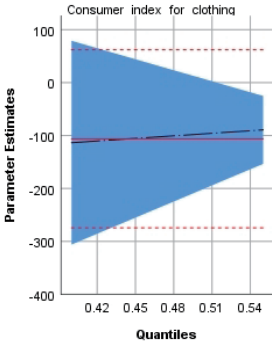
(g) Toal annual import of cotton



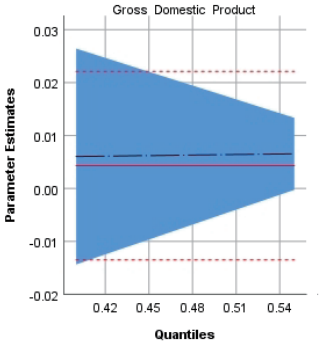
(h) Consumer Price Index



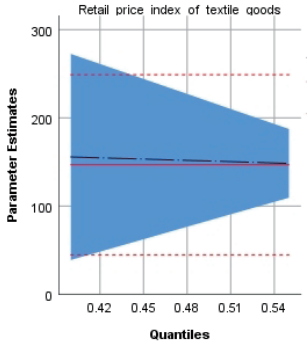
(i) Consumption level of residents



(j) Consumer Index for clothing



(k) Gross Domestic Product



(l) Retail price index of textile goods

greater than the increase in supply. At this point, even if the output increases, the price will also increase.

(2) Exported cotton volume: The increase in cotton export volume will reduce the domestic cotton hoarding volume, and the cotton price will increase.

(3) Amount of imported cotton: The increase in the price of cotton imports leads to an increase in the amount of cotton imported and the cost of cotton, which leads to an increase in cotton prices.

(4) Gross domestic product: With the increase of GDP, the per capita output value will increase accordingly, and the living standard of residents will improve. The increase in the demand for clothing has led to an increase in the demand for cotton, and the price of cotton has risen accordingly.

TABLE 3. Parameter estimation at quantile $\tau = 0.4$

Parameter	Parameter estimation with different quantiles						
	Coefficient	Standard Error	t	Degree of freedom	Significance	95% Confidence interval	
						Lower limit	Upper limit
Intercept	3746.598	10025.1086	0.374	3	0.733	-28157.772	35650.968
Cotton unit area production	-1.905	3.2439	-0.587	3	0.598	-12.228	8.419
Total cotton production	0.431	0.6976	0.617	3	0.581	-1.789	2.651
Cotton sown area	-0.589	0.8718	-0.675	3	0.548	-3.363	2.186
Total value of cotton exported annually	-20.452	4.6919	-4.359	3	0.022	-35.384	-5.52
Total annual export of cotton	0.025	0.0057	4.48	3	0.021	0.007	0.043
Total value of cotton imported annually	0.076	0.0756	0.999	3	0.392	-0.165	0.316
Total annual import of cotton	-0.503	1.3459	-0.374	3	0.734	-4.786	3.781
Consumer Price Index	-12.273	4.3744	-2.806	3	0.068	-26.195	1.648
Consumption level of residents	-0.056	0.2773	-0.203	3	0.852	-0.939	0.826
Consumer index for clothing	-113.495	60.464	-1.877	3	0.157	-305.919	78.928
Gross Domestic Product	0.006	0.0064	0.942	3	0.416	-0.014	0.026
Retail price index of textile goods	155.727	36.694	4.244	3	0.024	38.95	272.503

(5) Textile retail price index: With the increase of the textile retail price index, cotton as a textile raw material will have a greater demand, so that the sales price of cotton will increase accordingly.

- Negative factors.

(1) Cotton output per unit area: As the cotton output per unit area increases, the supply will increase accordingly. In the case of constant demand, the price of cotton sales will decrease accordingly.

TABLE 4. Parameter estimation at quantile $\tau = 0.55$

	Parameter estimation with different quantiles						
Parameter	Coefficient	Standard Error	t	Degree of freedom	Significance	95% Confidence interval	
						Lower limit	Upper limit
Intercept	3485.082	3345.2419	1.042	3	0.374	-7160.971	14131.135
Cotton unit area production	-2.868	1.0824	-2.65	3	0.077	-6.313	0.577
Total cotton production	0.595	0.2328	2.558	3	0.083	-0.145	1.336
Cotton sown area	-0.783	0.2909	-2.691	3	0.074	-1.709	0.143
Total value of cotton exported annually	-20.293	1.5656	-12.961	3	0.001	-25.275	-15.31
Total annual export of cotton	0.025	0.0019	13.115	3	0.001	0.019	0.031
Total value of cotton imported annually	0.068	0.0252	2.7	3	0.074	-0.012	0.148
Total annual import of cotton	-0.633	0.4491	-1.409	3	0.254	-2.062	0.796
Consumer Price Index	-12.892	1.4597	-8.832	3	0.003	-17.537	-8.247
Consumption level of residents	-0.059	0.0925	-0.64	3	0.568	-0.354	0.235
Consumer index for clothing	-89.275	20.176	-4.425	3	0.021	-153.484	-25.066
Gross Domestic Product	0.007	0.0021	3.064	3	0.055	0	0.013
Retail price index of textile goods	148.465	12.2443	12.125	3	0.001	109.498	187.432

(2) Cotton planting area: The increase in planting area will also increase the supply of cotton. The market is full of supply and prices will be lower.

(3) Cotton export amount: The increase in the total amount of cotton exports includes factors such as trade barriers (such as tariffs, etc.), which will affect the export volume of cotton, so that the domestic cotton stockpile is sufficient, and the sales price of cotton will decrease accordingly.

(4) Imported cotton volume: The more imported cotton volume, the more cotton hoarding volume. The market demand for cotton will not surge in the

TABLE 5. Parameter estimation at different quartiles

	Parameter estimation with different quantiles	
Parameter	$\tau = 0.4$	$\tau = 0.55$
Intercept	3746.598	3485.082
Cotton unit area production	-1.905	-2.868
Total cotton production	0.431	0.595
Cotton sown area	-0.589	-0.783
Total value of cotton exported annually	-20.452	-20.293
Total annual export of cotton	0.025	0.025
Total value of cotton imported annually	0.076	0.068
Total annual import of cotton	-0.503	-0.633
Consumer Price Index	-12.273	-12.892
Consumption level of residents	-0.056	-0.059
Consumer index for clothing	-113.495	-89.275
Gross Domestic Product	0.006	0.007
Retail price index of textile goods	155.727	148.465

short term, which will lower the price of cotton.

(5) Consumer Price Index: The larger the consumer price index, the higher the price. At this time, the sales volume of cotton will decrease due to the increase in price, the amount of cotton hoarding will increase, and the sales price will decrease.

(6) Residents' consumption level: Residents' consumption levels increase, and residents' purchasing power increases. The increased demand for other materials (such as silk) will be detrimental to the sales of cotton, thereby reducing the price of cotton.

(7) CPI for clothing: The increase in the CPI for clothing indicates that the cost of clothing increases. Whether it is the price of clothing or the profit of clothing, it is not conducive to the sales of cotton, which further increases the stock of cotton and reduces the sales price.

5. Conclusion and suggestions

The price of cotton fluctuated greatly around 2010, which was related to the global financial crisis that year. Therefore, when analyzing the relevant data of the cotton industry, the impact of emergencies should be fully considered. International cooperation and net profit are two prominent aspects. There is no doubt that both economic development and scientific and technological progress will greatly promote international cooperation. There are many factors that affect net income, such as economy, technology, and labor, which will have a significant impact on it. At the same time, the unit net profit may be negative, indicating that cotton farmers will not be able to obtain income only by planting cotton, but need to process cotton products before selling. Although the processing of cotton products requires costs,

the processed products have higher added value and more benefits. Under normal circumstances, cotton production increases year by year, cultivated varieties will survive the fittest, and varieties with high yield and good quality will gradually occupy the market. The increase in unit yield will control the planting area to a certain extent. China has strong potential in the international market, and the supporting policies issued by the government will support entrepreneurs and cotton farmers to seize the major opportunities in the international cotton market.

Based on the above SWOT analysis and quantile regression analysis of China's cotton industry, we make the following suggestions to the government and cotton farmers.

- The government should introduce preferential policies, provide economic subsidies, and encourage cotton farmers to actively engage in production.
- The government strengthens the training of skilled workers, and gradually forms a professional and technical team with reasonable staffing.
- The government should reasonably set the R&D ratio of the cotton industry, increase the output of cotton planting, and improve the quality of cotton products.
- The government strengthens supervision over the production and sales of cotton products, regulates market competition, and establishes a complete production supply chain.
- The government appropriately adjusts the import/export ratio to balance the market price of cotton and increase the share of Chinese cotton in the international market.

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Appendix A. Relevant policies

Table 6. Policies of textile industry from May 2017 to December 2018

Schedule	Policy	Details
December 2018	Spinning preparatory and spinning machinery-Rubber tubes of the coverings for the top rollers	From April 1, 2017, the latest standards including "Spinning preparatory and spinning machinery - Rubber tubes of the coverings for the top rollers (FZ/T93051-2016)", "National coarse sand bobbin (FZ/T93029-2016)", "Linking machine (FZ/T970362016)", "General technical requirements of cams on circular weft knitting machine (FZ/T97010-2016)" and "Spandex warping machine (FZ/T97037-2016)" will be implemented.
January 2018	Environmental Protection Tax Law	It is clear that textile wastewater mainly includes five types of wastewater from printing and dyeing, wastewater from chemical fiber production, wastewater from wool washing, wastewater from hemp degumming and wastewater from chemical fiber pulp.
July 2017	Action Plan for Green Development of China's Chemical Fiber Industry	By 2020, the concept of green development has become a common requirement for the entire production process of the chemical fiber industry. The green development promotion mechanism of the chemical fiber industry is basically formed. Green design, green manufacturing, green procurement, green process technology, and green chemical fiber products will become new growth points for the chemical fiber industry. The overall level of green development of the chemical fiber industry has been significantly improved.
May 2017	On the issuance of mandatory standards integration and streamlining the conclusion of the notice	The Ministry of Industry decided to repeal the "davit rod" and other 150 mandatory industry standards, including one in the textile industry, namely, "the provisions of the labeling of drawings of pressure vessel products.

TABLE 7. Policies of textile industry from November 2016 to December 2016

Schedule	Policy	Details
December 2016	Ministry of Industry and Information Technology "Administrative Measures for the Pilot Demonstration Park (Platform) of Textile and Apparel Creative Design"	The competent department of industry and information technology promotes the construction of pilot demonstration parks (platforms) for textile and apparel creative design, aiming to build a group of textile and apparel creative design parks (platforms) with strong resource gathering capabilities and high professional service levels through pilot demonstrations and typical leadership. The demonstration park (platform) will help the industry to increase varieties, improve quality, create brands, and promote the transformation and upgrading of the textile and garment industry.
November 2016	Announcement No. 26 [2016] of the Development and Reform Commission of the People's Republic of China and the Ministry of Finance of the People's Republic of China	According to the relevant arrangements of the National Development and Reform Commission and the Ministry of Finance Announcement No. 9 in 2016, according to the current situation of cotton supply and demand and market operation, it has been decided after research that during the new cotton market this year (currently until the end of February next year), the rotation of reserve cotton will not be arranged. In 2017, the sales of reserve cotton will start from March 6, and the deadline is tentatively set at the end of August. The daily listed sales volume is tentatively arranged at 30,000 tons. If the domestic and foreign market prices rise significantly and rapidly within a period of time, and the transaction rate of reserve cotton auction sales exceeds 70% for more than three days a week, the number of daily listings will be appropriately increased and the period of rotation sales will be extended.

TABLE 8. Policy of textile industry in July 2016

Schedule	Policy	Details
July 2016	"Guidance on the Development of Filament Finger Weaving Industry in the 13th Five-Year Plan"	By 2020, the output of China's long silk manufacturing industry will reach 51 billion meters, with an average annual growth of 3.33% and annual product profit margin 5.4%. The production efficiency of enterprises is greatly improved, and the inventory of finished products is significantly reduced. The export volume of China's chemical fiber factory silk fabric will reach 14 billion meters, with an average annual growth of 3.85%, gradually shortening the price difference with the same imported products in the international market, increasing the added value of products, and enhancing the international market value of filament fabric products. The r& d investment intensity of filament weaving enterprises above the scale should reach more than 1.5%. The production value rate of new products should increase from 30% to 40%. The proportion of high-grade and high value-added products should increase from 20% to 30%, and the application rate of non-water-jet new looms should take up 20%. Application penetration rate increased to 10%, realizing the development and application in the field of super fine denier fiber, multi-fiber composite, yarn-dyed and so on. The penetration rate of new pulping, slitting warping and twirling machines should increase to 15%.

Appendix B. Industrial data

Table 9. Data on unit production, total production, planting area, total export value, total export weight & total import value

Year	Unit production (kg/ha)	Total production (kiloton)	Planting area (1000ha)	Total export value (million dollars)	Total export weight (ton)	Total import value (million dollars)
2003	950.92	4859.71	5110.52	132.57	112020	1168.85
2004	1110.78	6323.51	5692.87	15.74	9092	3176.24
2005	1128.88	5714.18	5061.8	7.91	4962	3196.79
2006	1295.26	7532.79	5815.67	23.73	12956	4868.41
2007	1461.35	7597.13	5198.69	32.53	21004	3479.16
2008	1370.26	7232.35	5278.08	34.1	16361	3492.38
2009	1390.47	6235.84	4484.7	18.12	8249	2114.64
2010	1321.67	5770.39	4365.97	9.21	6453	5655.86
2011	1440.95	6518.85	4523.99	78.73	25698	9468.74
2012	1515.73	6608.02	4359.62	36.8	17558	11804.25
2013	1509.21	6281.57	4162.15	15.17	6733	8441.35
2014	1508.32	6299.44	4176.47	30.07	13470.18	4991.48
2015	1564.88	5907.39	3774.98	48.89	28915.68	2572.12
2016	1670.51	5342.84	3198.32	15.25	7757	1570.08
2017	1769.47	5652.52	3194.73	33.58	17083	2189.77
2018	1819.33	6102.77	3354.41	93.65	47349	3171.76

Table 10. Data on total import weight, consumer price index, clothing consumption index & consumer consumption level

Year	Total Import Weight (10 kiloton)	Consumer Price Index (1978=100)	Clothing Consumption Index (Previous Year=100)	Consumer Consumption Level (yuan)
2003	87	438.7	97.8	4555
2004	191	455.8	98.5	5071
2005	257	464	98.3	5688
2006	364	471	99.4	6319
2007	246	493.6	99.4	7454
2008	211	522.7	98.5	8505
2009	153	519	98	9249
2010	284	536.1	99	10575
2011	336	565	102.1	12668
2012	513	579.7	103.1	14074
2013	415	594.8	102.3	15586
2014	243.92	606.7	102.4	17220
2015	147.49	615.2	102.7	18857
2016	90	627.5	101.4	20801
2017	116	637.5	101.3	22969
2018	157	650.9	101.2	25245

TABLE 11. Data on average cotton price, GDP & retail price index of textile goods

Year	Average Cotton Price (yuan/50kg)	GDP (100 million yuan)	Retail price index of textile goods (previous year=100)
2003	746.92	137422	99.3
2004	545.32	161840.2	100
2005	653.54	187318.9	99.8
2006	606.54	219438.5	100
2007	655.21	270092.3	100.2
2008	522.53	319244.6	100.5
2009	664.7	348517.7	99.6
2010	1238.26	412119.3	101.2
2011	902.55	487940.2	105.7
2012	912.11	538580	101.5
2013	933.62	592963.2	101
2014	666.39	643563.1	100.9
2015	595.15	688858.2	100.6
2016	738.12	746395.1	100.5
2017	736.73	832035.9	100.4
2018	728.19	919281.1	100.8

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