

Worldwide cotton production and trade during COVID-19 pandemic: An empirical analysis for a three-year observation

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Abstract

The COVID-19 pandemic has posed a significant impact on agriculture. Due to its importance in world trade and human life, the effects of the pandemic on the cotton economy were evaluated by using the data of important organizations such as the U.S. Department of Agriculture, the World Trade Organization, and International Cotton Advisory Committee in this study. With the Chow test, which measures of structural breaks, the effects of COVID-19 on cotton production and trade were examined. According to the Chow test results, the pandemic had no significant effect on cotton production, exports and imports in the People's Republic of China and Türkiye, while being highly influential on cotton production and exports in the U.S. and Brazil. Distinctively, in Pakistan, it had a significant impact on cotton production and import. It was observed that although the demand, trade and prices for cotton were descended, the cotton prices started to recover with the increase in demand in the third quarter of 2020. In June 2022, the highest peak in cotton prices was observed. As a conclusion, it is shown that cotton production and trade during the pandemic were affected in all countries except People's Republic of China and Türkiye. However, the marks of the effects of factors such as decreasing stocks, uncertainties in national economies, high inflation and increase in production costs on the cotton economy will be better understood in the coming years.

Keywords: agriculture; agricultural economy; cotton export; cotton fiber; cotton import

Introduction

Cotton plant

Cotton (*Gossypium* spp.), by being the most important fiber and oilseed crop, and the key material used in manufacture, contributes to the economies of many countries (Ozyigit *et al.*, 2017). As of 2023, cotton is cultivated in almost 130 countries and covering approximately 32 million hectares due to its importance in economy (USDA, 2023a). Cotton can be used in textile with its fibers and linters, its seeds can be used in edible oil production, its stalk and leaves can be used as soil enrichers, in livestock feed production, food packaging,

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stationery, gloves, pillows and bed sheets (Munir *et al.*, 2020; Shahrajabian *et al.*, 2020; Pandirwar *et al.*, 2023). Cottonseed oil is frequently used in food industry due to its high temperature frying properties (Zhang and Wedegaertner, 2021).

Within the Malvaceae family and *Gossypium* genus, there are four cultivated species: two diploids (*G. arboreum* L. and *G. herbaceum* L.) and two tetraploids (*G. hirsutum* L. and *G. barbadense* L.). *G. arboreum* L. is native to Asia and Africa as *G. herbaceum* L. is indigenous to sub-Saharan Africa and Arabia (Hiremani *et al.*, 2020; Nwachukwu and Ofoefule, 2020; Tokel *et al.*, 2022a). *G. barbadense* L. is native to South America and *G. hirsutum* L. is mainly found in Central America. Allotetraploid *G. hirsutum* L., also known as upland cotton, is the most widely cultivated species and emerged in the U.S. 1-1.5 million years ago as a result of hybridization of *G. herbaceum* or *G. arboreum* genome with the *G. raimondii* genome. Due to its high adaptability and yields, it is grown in 95% of the world's cotton fields today (Ali *et al.*, 2020; Xun *et al.*, 2021; Jan *et al.*, 2022; Tokel *et al.*, 2022a; Chen *et al.*, 2023; Wang *et al.*, 2023).

The sensitivity of the cotton plant to temperature, drought, insects, pathogens, and salinity significantly affects fiber quality and cotton production worldwide. In addition, factors such as global warming and increasing population gradually increase the importance of cotton yield and fiber quality (Hocaoglu-Ozyigit *et al.*, 2022; Prakash *et al.*, 2023). In recent years, genetically modified cotton, in which many desired genes can be transferred by biotechnological methods, has now made the cotton plant resistant to insect pests, diseases and herbicides (Ozyigit *et al.*, 2022; Tokel *et al.*, 2022b). Especially in important cotton producing countries such as Pakistan, temperatures reaching up to 50°C in summer create concern for the future of cotton production. Because factors such as high temperature cause physiological and biochemical changes in plants and disrupt their enzyme activities. Thus, environmental changes negatively affect production and yield (Manan *et al.*, 2022).

COVID-19 and the global economy

In late December 2019, several pneumonia cases of unknown etiology were reported in Wuhan, China. The cases were thought to be linked to the Seafood Market, where live and wild animals such as bats, dogs, snakes etc. were sold. In the following days, the market was closed on January 1, 2020, and the virus, later termed as severe acute respiratory syndrome coronavirus (SARS-CoV-2), was isolated from confirmed pneumonia patients. Those patients had symptoms such as fever, shortness of breath, lung infiltration and cough (Ozbey *et al.*, 2021; Ahmadi *et al.*, 2023; Naseer *et al.*, 2023). SARS-CoV-2 is a single stranded and enveloped RNA virus that can be transmitted from human to human mainly through droplets while sneezing or coughing (Jackson *et al.*, 2022; Sadirbaeva and Chekirov, 2022). Since SARS-CoV-2 is highly transmissible, the number of cases has increased rapidly worldwide. Just after the novel coronavirus disease was termed as novel coronavirus disease (COVID-19) by the World Health Organization (WHO), new cases were reported in Thailand, Japan, Korea, the USA, and Vietnam (Jiang *et al.*, 2020; Lee, 2020). In Europe, cases were reported in Germany, France, Spain, and Italy respectively, and thousands of people have died (Giovanetti *et al.*, 2020). Despite strict measures such as curfews, social distancing, mask using, suspending flights, shutdown of schools, restaurants, and cafes, which have been taken to reduce the effect of the pandemic, it continues to spread globally (Genc, 2020; Sun *et al.*, 2022).

Like other viruses that can evolve rapidly through mutations, variants of SARS-CoV-2, the causative agent of the COVID-19 disease, have been isolated from patients in different parts of the world in recent years. The most notable of these variants were named as Alpha, Beta, Gamma, Delta, and Omicron, respectively (Demirhan *et al.*, 2022; Biancolella *et al.*, 2023). As of September 28, 2023, a total of 770,875,433 confirmed cases were detected worldwide, and nearly 7 million people died due to COVID-19 (WHO, 2023).

While the battle was carried out for the COVID-19 health crisis, the global economy had to face a major shock. All growing sectors, especially the supply-demand system, tourism, and international trade, were greatly

hit by the pandemic due to the measures taken to prevent the spread of the virus (Ridley *et al.*, 2023; Zhao *et al.*, 2023). As the pandemic emerged, unemployment rates increased in many countries, while global business activities, manufacturing, factory outputs, and merchandise trade decreased significantly (Naseer *et al.*, 2023). The agriculture and food industry were also affected by the pandemic. Travel restrictions, lockdown measures and closure of borders have resulted in labor shortages. In countries that are dependent on migrant labor, there were difficulties in the production of vegetables and fruits that require intensive labor (Lioutas and Charatsari, 2021; Sridrar *et al.*, 2022). Declining stocks made it harder for farmers to resist supply shocks and unexpected crises since it caused households to not adequately store their harvests (Huss *et al.*, 2021).

Global cotton economy

Cotton, by being the most consumed natural fiber in the textile industry, is the key crop of since it is ecofriendly and non-allergic on human skin. It is considered one of the most profitable non-food crop due to its value in the global economy. More than 200 pairs of jeans or more than 1,200 t-shirts can be produced from one bale of cotton. The global retail market value of processing raw cotton products (seed, fibre and linter) has been reported to be more than USD 18 billion in 2021 and is expected to exceed USD 22 billion by 2027 (Khan *et al.*, 2020; IISD, 2023; USDA, 2023b). Moreover, approximately 350 million people are employed in the cotton-related sector including spinning, weaving, clothing, and farming (Wang *et al.*, 2019; Fairtrade Foundation, 2023). In India, one of the countries with the largest cotton fields, more than 50 million people are employed in cotton-related industries (Mondal *et al.*, 2020; Invest India, 2021).

According to the latest report of USDA published in September 2023, top cotton producing countries are People's Republic of China (later referred to as China), India, Brazil, U.S., Pakistan, Australia, and Türkiye. India and China account for almost half of the total cotton production in the world. However, in the report published in June 2022, which we included in the study to examine the analysis of the first 3 years of the pandemic, the top cotton producing countries were listed as follows: China, India, U.S., Brazil, Pakistan, Australia, and Türkiye (Table 1). It is seen that Brazil has reached the 3rd place by increasing cotton production as of the 2023 season (USDA, 2022a; 2023).

Like many crops, cotton agriculture and cotton economy have been affected by the pandemic in different ways. Due to unpredictable lockdown implementations, farmers could not sale and harvest, resulting in product loss (Saha and Bhattacharya, 2020). The closure of textile mills, the shortage of agricultural inputs and seasonal labor, the decline in cotton demand as well as in cotton prices adversely affected the sector (Clapp and Moseley, 2020; Lioutas and Charatsari, 2021). With the emergence of the first cases in the world, there was a significant drop in cotton prices. Textile mills in many countries such as China and Bangladesh cancelled previous agreements and refused to buy the cotton they bought. According to ICAC, the fiber industry saw the worst since the 2008-2009 crisis. However, with the decrease of lockdown applications towards summer, cotton prices recovered in the third quarter of 2020. The uptrend was noticeable from April 2020 to June 2022 (ICAC, 2022).

On June 5, 2020, with the recommendation of using masks to prevent transmission of the virus in the guide published by WHO, the demand for masks has increased all over the world. Even though, personal hygiene products and clothes of health workers increased the interest and need for cotton, global consumption and trade volume decreased up to 10 percent in 2020 (Genc, 2020; Sadirbaeva and Chekirov, 2022). Meanwhile, at the World Trade Organization (WTO) meetings, attention was drawn to the importance of cotton in the recovery of the world economy after the pandemic (WTO, 2021). As the demand for clothing and apparel decreased with the closure of the stores and shutdowns, a sharp fall was observed in apparel imports, especially in the U.S. and EU countries, when the pandemic was on the rise in March-April 2020. The world cotton prices fell significantly in the first quarter of 2020. In some least developed countries that are top cotton producers, cotton export values decreased by 34% in 2020, a decrease of over USD 500 million compared to

2019 although there was an improvement in the cotton trade afterwards (Clase *et al.*, 2020; Muhammad *et al.*, 2021; WTO, 2021; USDA, 2022b).

On the other hand, the fact that social mobility came to a halt in the 2019/20 season caused devastating problems in the textile and apparel chain. With the decrease in interest in clothing, many stores closed. However, demand increased significantly in 2021 and the textile and clothing industry became the key sector that keeps the economies of many countries afloat. Although cotton prices start to fall again after June 2022, they remain above the pandemic period values (ICAC, 2022; USDA, 2023a).

Although, interest in cotton products increased with the decline of home office applications and the opening of schools and entertainment venues, there are concerns such as the emergence of new variants, changes in spending patterns, low global growth, and war between Russia and Ukraine are expected to reduce consumption and prices of cotton products as both countries produce nearly a half of the world's total cottonseed oil, as well as fertilizers including nitrogen and potash (ICAC, 2021; Tokel, 2021; Nchasi *et al.*, 2022; USDA, 2023a).

In accordance with the information in the introduction section, it was decided that analyzing 7 countries that play a key role in cotton production and cotton trade in the world within the scope of the study would make a significant contribution to the literature.

Materials and Methods

To better understand the effects of the pandemic on the world cotton economy, the production, export, and import values of the countries were examined with the Chow Break Test. Chow (1960) emphasizes that crises, wars and other impactful events, have the potential to distinctly differentiate periods in the history of countries. It is stated that the World War II changed the consumption and behaviour patterns in countries, especially the U.S., and that the before and after of these breaking periods are different. The COVID-19 pandemic period has deeply affected the economies of the countries. The changes in cotton production, export and import in the countries examined within the scope of this study were examined with the test developed by Chow (1960). The period of structural change in the Chow test is divided into two as before and after. If there is a significant difference between these periods, it is decided that there is a structural change. In the Chow test, the pre-fracture and post-fracture periods are considered homogeneous. In this test, the variance of the first period (σ_1^2) and the variance of the second period (σ_2^2) are considered equal and tested with the F test. In this case, the null hypothesis and F tests are shown as follows (Guris and Caglayan-Akay, 2013):

$$H_0 : \sigma_1^2 = \sigma_2^2 \quad (1)$$

$$F = \frac{\sigma_1^2}{\sigma_2^2} \quad (2)$$

In the Chow test, the null hypothesis states that there is no structural change whereas the alternative hypothesis states that there is a structural change (Guris *et al.*, 2013). In the study, analyses were made using annual data for the period 1991-2022 for China, India, U.S., Brazil, Pakistan, and Türkiye. To examine the effects of COVID-19 on cotton production and trade, cotton production, export and import data of countries were examined. In addition, to fully examine the structural breaks in cotton production, export, and import of countries during the COVID-19 period, the series were modelled with their own trends and the break in the series was examined. At the same time, the first case of COVID-19 appeared in China in December 2019 and was declared a pandemic by the World Health Organization in the first months of 2020 (Uras, 2021; WHO, 2022). Since the start year of the COVID-19 pandemic was considered to be 2020, this year was chosen as the break date. Eviews version 9 was used in the analysis (Eviews, 2023)

Results and Discussion

China

The textile industry is a key sector in the Chinese economy as more than 10 million people are employed (Arshad *et al.*, 2021). The value of the textile industry is USD 172.4 billion and contributes 1.9% of the gross domestic product (GDP) (Lehr, 2020; Xinhuanet, 2020). Cotton production is mainly carried out in the Xinjiang Uygur Autonomous region, where the yield is also the highest (Li *et al.*, 2020). As of 2023, China and India are the leading countries in cotton production. In contrast to India, the yield is significantly higher in China while the total cotton area is much lower (USDA, 2023a).

In the first months of the pandemic, the Chinese national economy reached its worst level since 1992 (Liu, 2021). However, the thought that the source of COVID-19 was animals has also led to the questioning of China's agri-food system. As of April 8, 2020, the lifting of travel restrictions by government decision has enabled the economy to revive. Despite the loss of wages for seasonal labors, there was no significant impact compared to other countries. In fact, the economy grew by 3.2% in the second quarter (Zhang and Hu, 2021). China is by far the leading country in cotton import. Therefore, China's trade affects the global cotton market. With the emergence of the pandemic, demand for clothing, apparel and other cotton products has reduced and therefore, the demand for cotton also decreased (Muhammad *et al.*, 2021). The long-term negative impact of the pandemic on cotton production become clearer since cotton production had not reached pre-pandemic values as of June 2022 (Table 1).

Table 1. Cotton production in the last 5 seasons (in thousand metric tons) of top cotton producing countries and forecasts for June 2022/23 season (USDA, 2022a)

Production in tmt	2018/19	2019/20	2020/21	2021/22	Jun 2022/23
China	6,042	5,933	6,423	5,879	5,987
India	5,661	6,205	6,009	5,334	5,987
U.S.	3,999	4,336	3,181	3,815	3,592
Brazil	2,830	3,000	2,356	2,765	2,874
Pakistan	1,655	1,350	980	1,306	1,350
Australia	479	136	610	1,197	1,197
Turkey	816	751	631	827	936
Others	4,254	4,407	4,083	4,337	4,478
Total	25,736	26,118	24,272	25,461	26,403

Domestic cotton consumption and cotton import have increased significantly in the 2020/21 season, whereas a decrease is observed as of June 2022. Cotton import increased from USD 8.28 billion in 2020 to USD 10.59 billion in 2021 and surpassed pre-pandemic levels. Following the emergence of the pandemic cotton exports dropped to USD 11 billion in 2020 but increased significantly in 2021 and reached approximately USD 13,68 billion. Ending stocks increased in the first year of the pandemic and it is expected to increase as of October 2022/23 season (Trading Economics, 2022a; 2022b; USDA, 2022a). Meanwhile, a new restriction on Chinese products has been added by the U.S. in January 2021. Cotton imports from China's Xinjiang region, which produces the most cotton, has been banned since the production is done by forced labor

of workers in the Uyghur region. In addition, the import of all clothing and textile products made with cotton grown in that region was also prohibited (Reuters, 2021).

It is reported that cotton production, export and import were significantly affected in China during the pandemic period. China's cotton production, export, and import for the period 1990-2022 are shown in Figure 1. It is seen that there is a break in cotton production, export and import in 2020, which is the beginning of the pandemic in China. Whether these breaks were statistically significant or not was analyzed with the Chow test. The Chow test results for China's production, export and import are shown in Table 2.

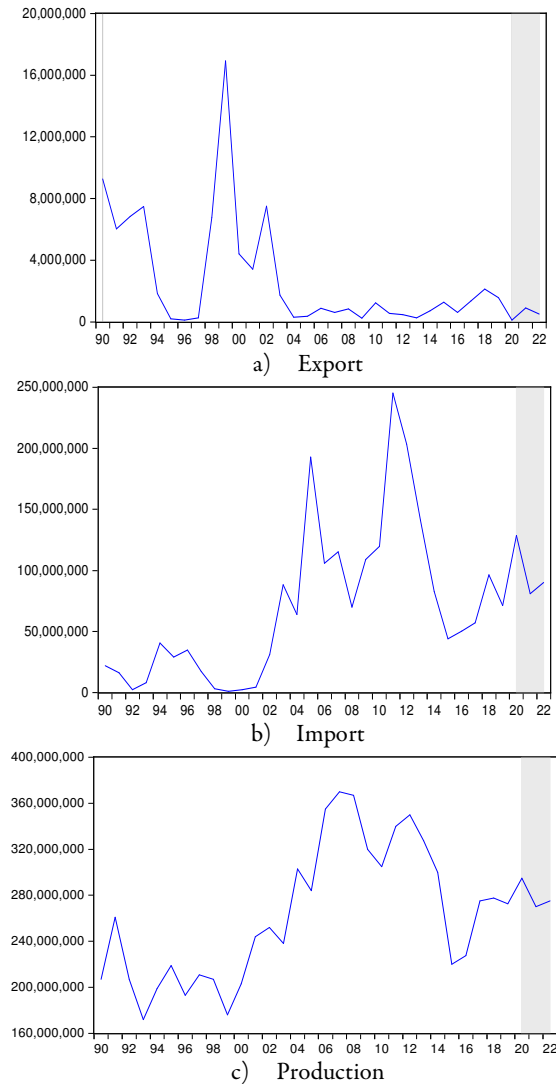


Figure 1. Cotton production, export, and import in China (1990-2022)

Note: The gray area shows the period after the COVID-19 period. Charts were created by the authors with data taken from (United States Department of Agriculture (USDA) Foreign Agricultural Service, 2022c).

Table 2. Chow test results for China

Statistics	Production	Export	Import
F-statistic	1.042017	0.144013	0.639939
prob-F	0.3656	0.8665	0.5346

Note: In the Chow test, its trend is used as a regressor. * %1, ** % 5 and *** % 10 are significant.

While examining the effects of a 3-year COVID-19 period on cotton production, exports, and imports in China, 2020 was considered a breaking year. According to the results of the Chow test, no statistically significant structural break was detected between the COVID-19 period and other periods. As seen in the figures, there are small breaks in 2020, but these breaks are temporary, and their effects are limited. Figures support Chow test results. It can be said that the measures and policies taken in China limited the effects of the pandemic on cotton production and trade.

India

Cotton production is carried out mostly in Maharashtra, Gujarat, Madhya Pradesh, Andhra Pradesh, and Haryana states. According to the latest report of Government of India Ministry of Textiles, there are 5.8 million cotton farmers and approximately 50 million people are employed in cotton related industries. The cotton sector has a significant role in the Indian economy and therefore, it is termed as “white gold” (Shinde *et al.*, 2020; Ministry of Textiles, 2023). The domestic textile industry is valued at approximately USD 101 billion and contributes 2% of GDP (USDA, 2020a; Invest India, 2021). Although India is the second leading country in cotton production, the yield is quite low (USDA, 2022a; 2023).

With the largest population in the world, the measures taken by the government were inadequate with the detection of cases in people coming from abroad. At the beginning of the pandemic, a USD 25 billion aid package was offered for the benefit of farmers (Varshney *et al.*, 2021). After the first cases, the government imposed a lockdown on March 22, 2020, when agricultural activities were at their peak (Singh *et al.*, 2020). It is estimated that the country lost USD 4.5 billion during the 21-day quarantine application. (Kumar *et al.*, 2021). According to a survey conducted in May 2020, it was determined that 11% of the farmers in the country could not harvest their products due to unfavorable weather conditions (37%) and lockdowns (24%), and nearly half of the farmers were unable to sell their products harvested for similar reasons (Jaacks *et al.*, 2021). With the intervention of the government, Minimum Support Price (MSP) program in India, private players including cotton traders and factories, continued to purchase large amounts of cotton in the 2020/21 season. The amount of cotton purchased since November 2019 was one third of the total crop. MSP delays the entry of cotton into the trademark, stabilizing prices and at the same time providing cash support to farmers (The Times of India, 2021). In 2020, cotton import fell by half to USD 123.31 million due to the large amount of cotton purchased by the private players. In 2021, import doubled and reached USD 259.39 million. Following the pandemic, cotton exports dropped in 2020 and reached approximately USD 6 billion whereas it surged and surpassed the pre-pandemic levels by reaching USD 10.03 billion in 2021. Although cotton production decreased after the pandemic, it was expected to exceed pre-pandemic values in 2022. However, it is still below pre-pandemic levels (Table 1). Domestic cotton consumption increased rapidly in 2020/21 season whereas ending stocks has been decreasing (Trading Economics, 2022c; 2022d; USDA, 2022a; 2023a). The development of cotton production, exports, and imports in India during 1990-2022 is shown in Figure 2.

Cotton exports and imports were significantly affected in 2020, when the pandemic started in India. There seems to be a significant break especially in cotton exports. The effects of COVID-19 on cotton production and trade in India were examined with the Chow test and the results are shown in Table 3. As understood in the Chow test, there is a statistically significant difference between the pandemic period and the previous period in cotton production, export and import in India. It is seen that the breaks detected in Figure 2 (a, b, c) are significant. In other words, it is understood that the 3-year COVID-19 period affected cotton production and trade.

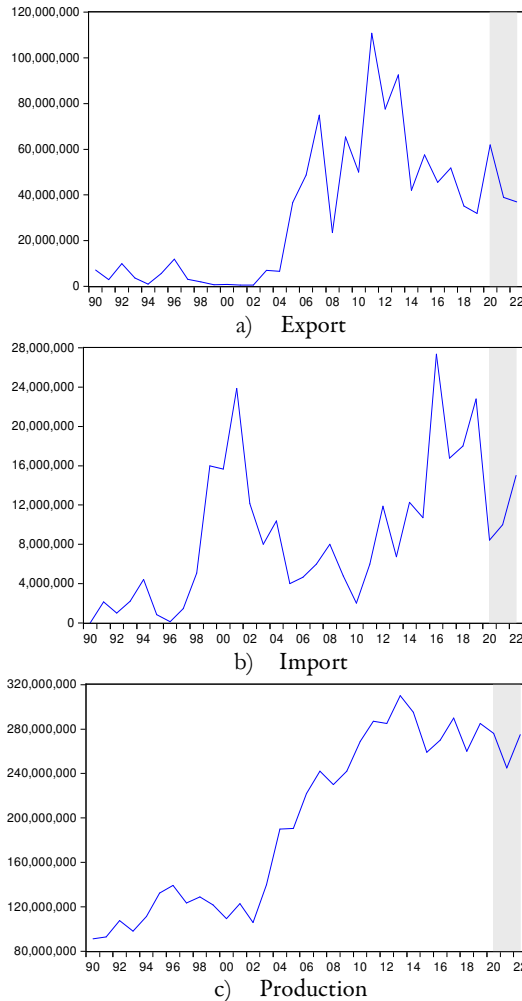


Figure 2. Cotton Production, Export, and Import in India (1990-2022)

Note: The gray area shows the period after the COVID-19 period. Charts were created by the authors with data taken from (United States Department of Agriculture (USDA) Foreign Agricultural Service, 2022c).

Table 3. Chow test results for India

Statistics	Production	Export	Import
F-statistic	4.743145	4.619451	3.022020
prob-F	0.0165**	0.0395**	0.0921***

Note: In the Chow test, its trend is used as a regressor. * %1, ** % 5 and *** % 10 are significant.

United States

In the U.S., the world’s leading cotton exporter, production is mainly carried out in the states of Texas, Mississippi, Arizona, and Arkansas (USDA, 2020b). Cotton and the related sectors are estimated to be worth nearly USD 120 billion (Aslam *et al.*, 2020). Cotton contributes nearly 4% of GDP and 125 000 people are employed in the sector (USDA, 2019; 2020c). Lockdown measures adversely affected many important sectors, especially agriculture and manufacturing in 2020. However, U.S. cotton prices recovered rapidly as the demand increased, as of October 2021. The fall in prices can be thought of as a decline in interest in new clothing due to global shutdowns (Aljazeera, 2020; Weersink *et al.*, 2021; USDA, 2022a; Yaddanapudi *et al.*, 2022). Moreover, the U.S. had experienced a labor shortage as almost half of the workforce is foreign-born and comes mostly from Mexico (Charlton and Castillo, 2021). The previous problems in supply and demand at the

beginning of the pandemic affected farmers, distributors, and the agricultural sector. The effects in the agricultural sector appeared to be short-lived, as the government's support for cotton to farmers through the coronavirus food assistance program (USD 0.3 billion) (Orden, 2021). However, the U.S. has experienced one of the sharpest declines in cotton production in 2020/21 season and as of 2023, production is still below pre-pandemic levels (Table 1) (USDA, 2023a). Cotton exports which dropped nearly a half to USD 7 billion in 2020, recovered rapidly and reached USD 7.16 billion in 2021. Almost no cotton was imported in 2020 and 2021. While domestic consumption increased slightly, ending stocks also decreased by half. Ending stocks have been decreasing since the 2020/21 season (Trading Economics, 2022e; USDA, 2022a; 2023a). The evolution of cotton production, exports and imports in the U.S. is shown in Figure 3.

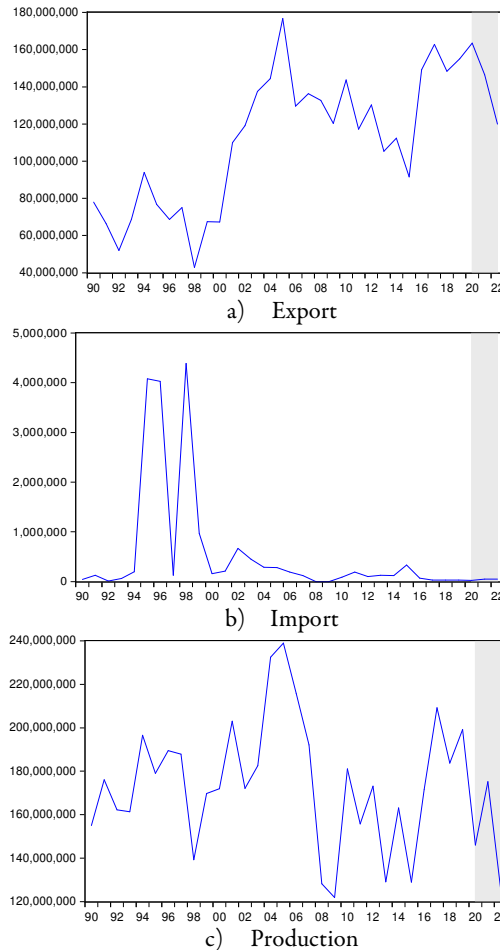


Figure 3. Cotton production, export, and import in U.S. (1990-2022)

Note: The gray area shows the period after the COVID-19 period. Charts were created by the authors with data taken from (United States Department of Agriculture (USDA) Foreign Agricultural Service, 2022c)

It can be seen that cotton exports and production in the U.S. were significantly affected during the pandemic period, but low cotton imports were not affected by this period. It was checked whether these breaks in cotton production and exports during pandemic had a significant impact and the results are shown in Table 4. According to the results of the Chow test, it is understood that there is a statistically significant break in cotton production and export in the U.S. In addition, Figure 3 (a and c) supports this situation. However, it is understood that the import acted independently of this 3-year-pandemic period.

Table 4. Chow test results for U.S.

Statistics	Production	Export	Import
F-statistic	4.118336	3.919802	0.568395
prob-F	0.0511***	0.0567***	0.4566

Note: In the Chow test, its trend is used as a regressor. * %1, ** % 5 and *** % 10 are significant.

Brazil

In Brazil, cotton is mainly cultivated in Mato Grosso and Bahia states (Barros *et al.*, 2020). Approximately 10 million people, 75% of whom are women, are employed in the cotton-related sectors. It is estimated that approximately USD 30 billion was earned from cotton related industries, including textile and apparel which contribute nearly 27% of GDP (Tex Brasil, 2021a, 2021b; Trading Economics, 2021). As of April 2020, the number of cases and mortality rate in Brazil surpassed most countries (Ponce, 2020). Industry and agriculture-related sectors are among the sectors most affected sectors by the pandemic (de Paulo Farias and Fernandes de Araújo, 2020). As of 2020, cotton prices dropped and production costs (fertilizer, herbicides, supply of machinery, labor) increased as in other countries. However, after the sharp decline in May 2020, the upward trend in the price of Brazilian cotton continues until today. The production, which decreased in the 2020/21 season, recovered as of the 2022/23 season and reached pre-pandemic levels (Table 1). (USDA, 2023a). Even for a short time, Brazil turned the pandemic and trade war between China and the U.S. into an advantage and increased the cotton exports up to USD 3.3 billion and USD 3.59 billion, in 2020 and 2021 respectively. There was a significant increase in cotton import from nearly USD 100 million in 2020 to USD 151.86 million in 2021. Ending stocks and consumption increased and reached pre-pandemic levels as of 2022/2023 season after a decrease after the pandemic. It can be said that the 2019/20 season was one of the best years for Brazilian cotton. While there have been lockdowns and shipment delays, Brazil maintained exports of cotton lints (ICAC, 2021; Trading Economics, 2022f; 2022g; USDA, 2022a; 2023a). Cotton production, export, and import in Brazil for the period 1990-2022 are shown in Figure 4.

In Figure 4 (a, b, c), it is seen that cotton production and exports in Brazil experienced significant fluctuations during the pandemic period. The significance of these fluctuations was tested with the Chow test and the results are shown in Table 5. As a result of the Chow test, it is seen that there was a significant break in cotton production and export in Brazil during the 3-year-pandemic period. Additionally, Figure 4 (a, c) supports statistically significant breaks. As seen in Figure 4 (b), no statistically significant break was detected in cotton imports.

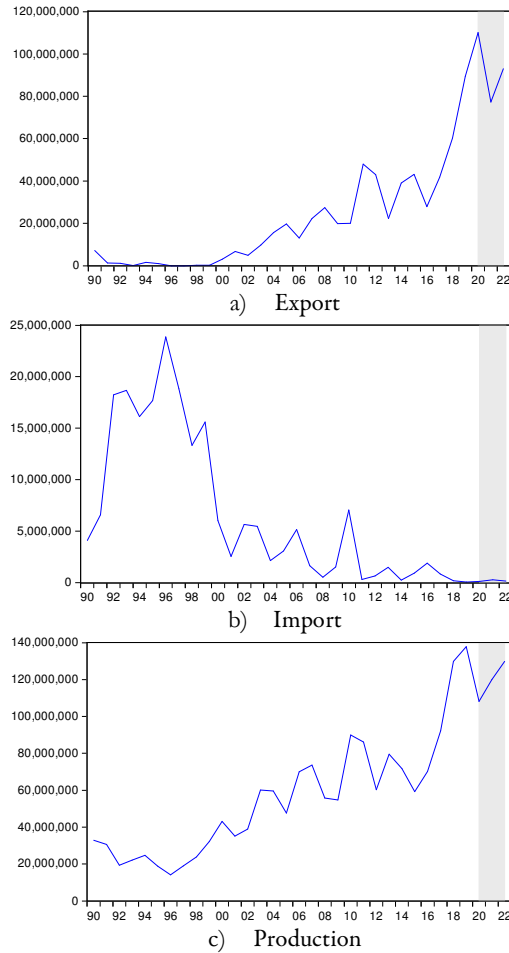


Figure 4. Cotton production, export, and import in Brazil (1990-2022)

Note: The gray area shows the period after the COVID-19 period. Charts were created by the authors with data taken from (United States Department of Agriculture (USDA) Foreign Agricultural Service, 2022c).

Table 5. Chow test results for Brazil

Statistics	Production	Export	Import
F-statistic	3.898878	12.10598	0.578475
prob-F	0.0316**	0.0002*	0.5671

Note: In the Chow test, its trend is used as a regressor. * %1, ** % 5 and *** % 10 are significant.

Pakistan

The most important cash crop after wheat, cotton is the most widely grown crop and mainly grown in the provinces of Sindh and Pinjab (Rehman *et al.*, 2019; Abbas, 2020). The cotton sector has a share of approximately 1% of the country’s GDP and is valued at USD 7.72 billion (Memon, Aziz and Qayyum, 2020; Ullah *et al.*, 2020). Additionally, textile sector is the largest industrial sector in Pakistan and contributes 8% of GDP. Approximately 11.5 million people work in textile sector and there are 1.5 million farmers who only grow cotton. More than 90% of cotton is produced by small farmers (USDA, 2020d; 2021b). The challenges experienced by China due to the pandemic could have given Pakistan an advantage by increasing its exports and production, especially in textiles (Sareen, 2020). However, the curfew imposed in Sindh, the industrial center of the country, affected exports as most of the factories were unable to work. Additionally, in key agricultural provinces, harvesting has become more difficult due to the lack of labors and prohibited transport

(Shafi *et al.*, 2020). On the other hand, more than a quarter of the population in Pakistan struggles with food insecurity and this number is expected to increase in the coming years (Ubaid-ur-Rehman *et al.*, 2021; Cheema *et al.*, 2022).

Moreover, due to factors such as poor-quality seeds, technological inadequacy and climate change, the Pakistani government stated that the 2020/21 season was a critical year for cotton crop. It was believed that there is a need to promote production with “Revival cotton” reforms (Dawn, 2021). Furthermore, in August 2019, the governments of Pakistan and India mutually suspended trade relations between the two countries. In this context, cotton import and export stopped between the two major cotton producers. However, in April 2021, Pakistan took a decision to meet the domestic cotton need by lifting the cotton import ban from India (ICAC, 2021; USDA, 2021a). Meanwhile, as farmers struggle with pink bollworm attacks, it was decided to plant cotton after April as timing of their activity was considered. In addition, European Union’s “Generalized System of Preferences-Plus” scheme to Pakistan is expected to encourage cotton production and the textile sector (ICAC, 2021; USDA, 2021b).

Despite the measures taken, the 2020/21 season was one of the worst seasons for Pakistan, with a decrease of nearly 30 percent in cotton production since 1983. Production shows decreasing or increasing trends over the years, and although production is expected to increase significantly in the 2023/24 season, it is still below pre-pandemic levels (Table 1) (USDA, 2023a). Cotton import surged and broke records both in 2020 and 2021 by reaching USD 1.39 billion and USD 1.91 billion, respectively. Meanwhile, cotton export dropped to USD 2.64 billion in 2020. Even though exports increased to USD 3.4 billion in 2021, it could not reach pre-pandemic levels. Cotton consumption, which decreased in the 2022/23 season, is expected to increase in the 2023/24 season. (Trading Economics, 2022h; 2022i; USDA, 2022a; 2023a). The development of cotton production, exports, and imports in Pakistan during 1990-2022 is shown in Figure 5.

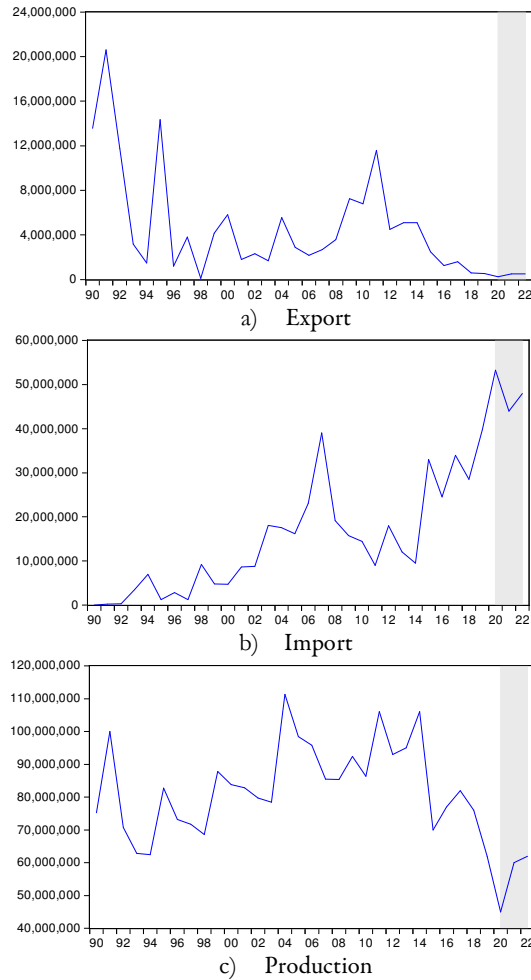


Figure 5: Cotton Production, Export, and Import in Pakistan (1990-2022)

Note: The gray area shows the period after the COVID-19 period. Charts were created by the authors with data taken from (United States Department of Agriculture (USDA) Foreign Agricultural Service, 2022c).

It is seen that cotton production and imports were affected during the 3-year-pandemic period in Pakistan. However, it is understood that exports were affected relatively less from this process. The significance of the breaks in Pakistan's cotton production, exports and imports during the COVID-19 period was tested. The results of this test are shown in Table 6. As a result of the Chow test, it was determined that Pakistan's cotton production and imports were affected by the pandemic. In these variables, it is seen that there is a structural difference between the pre- and post-COVID-19 period. Figure 5 (b, c) supports these results. However, it has been determined that there was no statistically significant effect on cotton exports.

Table 6. Chow test results for Pakistan

Statistics	Production	Export	Import
F-statistic	7.971261	0.025387	13.63329
prob-F	0.0082*	0.9750	0.0009*

Note: In the Chow test, its trend is used as a regressor. * %1, ** % 5 and *** % 10 are significant.

Türkiye

Cotton is grown in Anatolia, Aegean, and Mediterranean regions. Due to the high demand, the amount of cotton produced in the country is not sufficient. Therefore, Türkiye has been one of the leading countries

in cotton import since the beginning of the 2000s (Basal *et al.*, 2019; ICAC, 2021; Tokel *et al.*, 2022a). Cotton-related sectors contribute 6% of the country's GDP, and it is known that approximately 2 million people are employed in these sectors. Annual gain in cotton-related industries is worth USD 29.4 billion (ICAC, 2019). In the last decade, a farmer support program has been established due to the decrease in the number of farmers in the country and their abandonment of agricultural lands. After the first cases were confirmed, measures such as curfews, closure of restaurants and cafes, hotels and suspending flights have been implemented for a year. Farmers have faced problems such as fluctuating prices due to the pandemic, closure of bazaars, difficulties in making shipment of products due to limited travels. Working conditions of farmers have become difficult due to curfews and age-related bans. Stockpiling and increased demand caused a rise in prices (Genc, 2020; Atalan-Helicke and Abiral, 2021).

On the other hand, due to the COVID-19 uncertainty and the depreciation of the Turkish lira, farmers turned to alternative crops (Tokel, 2021). In the first months of the pandemic, European countries have shifted their textile orders from China to Türkiye since the outbreak emerged in China. However, this situation did not last long, as pandemic hit Europe and Türkiye and the demand for cotton also decreased. Meanwhile, a significant amount of hydrophilic cotton suitable for medical use was exported (USDA, 2020e; 2020f; 2021c). According to the Istanbul Apparel Exporters' Association, Türkiye made a record level of apparel exports in 2020. These exports included pandemic-related clothing, accessories and masks which enabled the industry to invest USD 24.4 billion in 2020 (IHKIB, 2020). Cotton production, which recovered rapidly in the 2021/22 season, is expected to decrease in the 2023/24 season (Table 1) (USDA, 2023a). Cotton imports, which decreased by USD 2.5 billion in 2020, reached a record level in 2021 by reaching USD 3.71 billion (Trading Economics, 2022j; USDA, 2022a). Since March 2021, cotton yarn manufacturers have been operating at full capacity, and it is expected that the young population, investments in technology and agriculture, increasing number of stores and growing urban areas will have a positive impact on cotton production in the long run. Domestic consumption and ending stocks have been increasing since 2020/21 season. Cotton exports, which decreased significantly in 2020 and was worth USD 1.5 billion, reached a record level of USD 2.27 billion in 2021 (Trading Economics, 2022k; USDA, 2021a; 2021c; 2022a).

The changes in cotton production, exports, and imports in Türkiye during 1990-2022 are shown in Figure 6. As cotton production increases in Türkiye, it is seen that cotton exports and imports also increase. After the deep break in cotton production in 2009, there was an increase in production. While cotton imports showed a continuous increase in the period of 1990-2022, export increased after 2008-2009. However, it is seen that there is only a break in cotton production during the 3-year-pandemic period in Türkiye and that imports and exports are not affected by this period. It has been investigated whether the COVID-19 period had a statistically significant effect on cotton production, exports and imports in Türkiye and the results are shown in Table 7. As a result of the Chow test, no statistically significant difference was found in cotton production, exports, and imports between before and after 2020, which was the beginning of the pandemic period. In other words, it seems that the pandemic period did not have a significant effect on cotton production and trade in Türkiye.

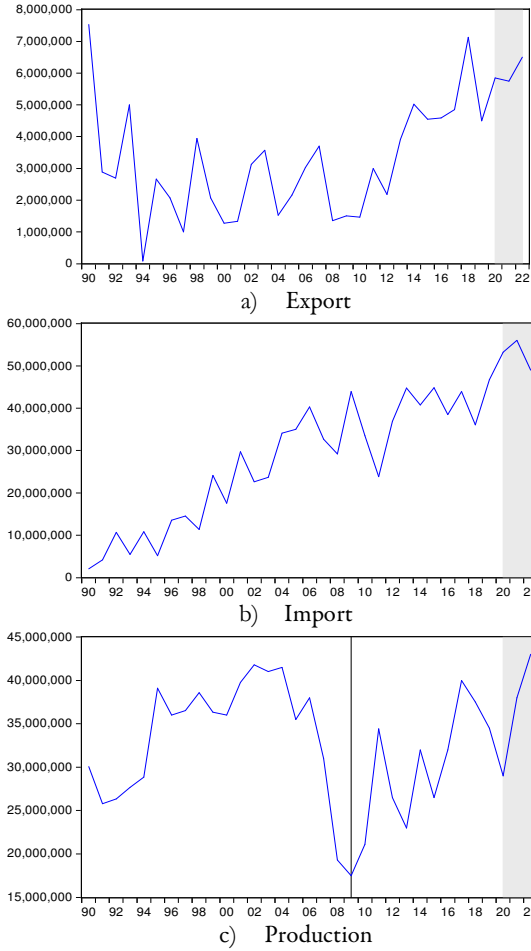


Figure 6. Cotton production, export, and import in Türkiye (1990-2022)

Note: The gray area shows the period after the COVID-19 period. Charts were created by the authors with data taken from (United States Department of Agriculture (USDA) Foreign Agricultural Service, 2022c).

Table 7. Chow test results for Türkiye

Statistics	Production	Export	Import
F-statistic	1.318263	1.475093	0.498117
prob-F	0.2597	0.2454	0.6128

Note: In the Chow test, its trend is used as a regressor. * %1, ** % 5 and *** % 10 are significant.

The COVID-19 pandemic, which shook the whole world, also affected agriculture and trade in different aspects. Within the scope of our study, it was investigated how the pandemic affected the leading cotton producing countries in the first 3-year period and the results were presented. Analysis and tests showed that cotton production, imports and exports of some countries were less affected by the pandemic than expected. For all these reasons, conducting such studies and analyzes will be useful in understanding the current situation and future of cotton agriculture.

Conclusions

COVID-19 has had significant impacts on cotton economy and agriculture in direct and/or indirect ways. However, these effects have emerged in different levels according to the agriculture and production

structure of the countries. Measures taken to prevent the spread of the virus, labor shortage, increased transportation costs, and decreased demand for clothing and apparel products affected the demand for cotton as well as the cotton trade. With the first shock of the pandemic, there were serious fluctuations in cotton trade and cotton prices in the first six months. There was a sharp increase in cotton prices in June 2020.

While the effects of the pandemic are expected to have devastating impacts on cotton agriculture, the analysis made as of today has clarified the situation of cotton agriculture and trade in the three-year period after the pandemic. As a result of the structural break tests conducted in our study, it was seen that the pandemic did not have a significant impact on cotton production, exports and imports in China and Türkiye. This is a surprising result as it shows that the effects of the pandemic remained limited despite the lockdowns and long-term restrictions in China, the origin of the pandemic. However, the pandemic had a significant effect on both cotton production and exports in the U.S. and Brazil. In Pakistan, the pandemic had a significant effect on cotton production and imports while exports were not affected. In addition, it is understood that cotton production is affected in all countries except China and Türkiye in the countries evaluated within the scope of the study. The impact of imports and exports varies depending on the structure of the countries.

The financial losses in the agricultural economies of the countries hit by the pandemic are now better understood with the release of data on cotton imports and exports. However, due to the use of the previous year's stocks, there was no shortage of cotton in the first year of the pandemic. The fastest recovery was seen in China which was also the first country affected by the pandemic. Although there was a sharp decline in global cotton consumption in the 2019/20 season, cotton consumption was expected to rise above pre-pandemic levels due to increased social activities and the lifting of bans. However, cotton consumption worldwide is still below pre-pandemic levels (USDA, 2023a)

In addition to the fact that the effects of the pandemic on the cotton farming vary among countries, the fight against the pandemic became more difficult in countries such as the U.S. and Pakistan, which are struggling with climate change, heavy rains, and high temperatures. One of the consequences of the pandemic is that the gaps and problems in the agriculture and the cotton sector have been noticed by the governments, but these need to be strengthened against sudden changes with reforms. In addition, the importance of migrant labors working in rural production systems is better understood and the necessary regulations must be made for them. It has been understood that in order for the agricultural sector to overcome the pandemic period with the least damage, farmers must be supported, easy credit opportunities must be provided, minimum support prices must be applied, and most importantly, primary agriculture must be protected from the severe effects of the pandemic.

After the temporary negative effects at the beginning of the pandemic, the economies of the countries recovered faster than expected as the number of people vaccinated increased day by day. However, this does not mean that the cotton market will recover quickly. Although total cotton consumption increases according to the forecasts for the coming seasons, it will be better understood how factors such as supply problems from China and India and the decrease in consumption in important cotton importers such as Bangladesh and Vietnam will affect the cotton market. In addition, the possibility that factors such as climate crisis, excessive rain and extreme drought, and economic uncertainty, wars, increasing cost of agricultural inputs will negatively affect the demand, production and trade for cotton continue to be a concern (USDA, 2023a)

Authors' Contributions

IIO conceived the study and he was in charge of overall direction and planning. M.Z and D.T. designed and performed the analysis and tests. All authors discussed the results and commented on the manuscript. BNE took the lead in writing the manuscript and obtaining the general data. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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