Market and Welfare Impact Assessment of the Target Price-Based Subsidy Program in the Chinese Cotton Market

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ABSTRACT

The Chinese pilot target-price-based subsidy program (TSP) on the cotton market in Xinjiang region started in 2014 and is regarded as an effective policy, motivating cotton farmers and reducing cotton imports. This paper develops and applies a partial equilibrium model of the cotton market with regional details and linkages to the rest of the world to quantify the market and welfare impacts of a nationwide TSP. The results show a significant increase in domestic output and decrease in imports without significantly reducing current national welfare as long as the target price does not go below 120 percent of market price. In addition, measures that restrict the release of cotton stock to the domestic market would help the government in reaching its objective of supporting cotton farmers and reducing import.

Keywords: target-price-subsidy, China's cotton market, welfare analysis, partial equilibrium

JEL Classification: Q18, Q11, C61

INTRODUCTION

China is an important player in the world cotton market. It has actively intervened in its domestic markets through various policy measures in order to stabilize or increase the self-sufficiency rate for cotton. Prior to 2010, China produced 30 percent of the world's cotton and contributed about the same share in global imports. However, since 2010, both exports and imports have fallen to 24 percent and 18 percent, respectively. Consequently, direct intervention policies have intensified.

With the rapid double-digit rate of annual increase in wages in China over the last decade, cotton production costs have been rising faster compared to the rest of the world (MacDonald, Gale, and Hansen 2015). The rising cost accompanied by a rapid reduction of the price of cotton during 2009-2010 prompted China's policymakers to strengthen their support for cotton production in 2011 through a price floor (CCA 2014; Yu 2017). The government set a minimum price in the domestic cotton market and purchased the excess supply directly from cotton farmers. The policy increased domestic production and eventually increased China's cotton stock to an average of 51 percent of the global cotton stock from 2011 to 2013. This raised the problem of costly cotton reserve management and lower cotton quality after longer storage periods. Additionally, the high price floor significantly increased the import of lower-priced raw and processed cotton by textile millers (Niu and Stanway 2013; MacDonald, Gale, and Hansen 2015; Shull, Clever, and Wu 2015).

Reacting to these developments, China switched its cotton policy to the Target-price-based Subsidy Program (TSP) in the autonomous region of Xinjiang, a major cotton producing region accounting for 67 percent of China's cotton output in 2016 (NBS 2016). Every three years before cotton planting starts, the Chinese central government sets a target price.[1] At the end of the year, this target price is compared with local market prices[2] to determine the amount of subsidy payable to producers. If the local market price is lower than the target price, cotton producers receive the difference between the two prices for each unit sold during the year. In other major cotton producing regions (i.e., Yangtze River and Yellow River regions, hereafter referred to as "Inland") the direct payment policy (DPP) replaced the price floor and producers receive a subsidy of Chinese Yuan (CNY) 2,000 (USD 322 in 2014) per ton of cotton delivered to the qualified purchasing and processing firms. The different policy settings across regions was intended to offer information on what countrywide program would best fit the government's objectives of bolstering production, reducing imports, and increasing societal welfare (Zhang and Du 2016).

After observing the outcomes, the government now regards TSP as a more effective policy to (a) support farmers in receiving a certain minimum level of revenue, (b) maintain a certain level of self-sufficiency that requires less policy adjustment compared with DPP, and (c) support farmers when necessary. Under DPP, farmers could receive subsidy payments even if prices are relatively high. This could happen when the direct payment amount is announced at the beginning of the period, and prices increase during the period. Furthermore, since there has been a tendency to reduce production of cotton in the Inland (Zhai 2019), several policy initiatives have been considered to further support cotton production in the region. For example, the state council of China has established protected zones for cotton

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[1] Target price = (cotton production cost from the last year × average growth rate of production cost from last 3 years) + (average net profit from last 3 years × the protection multiplier, which takes value between 0 and 1). The protection multiplier depends on the government's budget as well as the supply and demand conditions.

[2] The local market price is the regional average price paid by processors or grain depots during the peak cotton-purchasing season, i.e., between September and November, and not the price received by farmers.

planting in the Inland, where the number of the protected zones exceeds 30 percent of the total protected zones in China (SCPRC 2017; Association of Chinese Cotton & Linen Industry Economic Research 2017). In pursuit of a stronger support for cotton production, a nationwide TSP has also been considered (Qin 2016; Association of Chinese Cotton & Linen Industry Economic Research 2017; Yao 2017). Some studies like Yu (2016) evaluated the trade impact of such policy using a computable general equilibrium framework. Other studies focused on the design of the TSP and its implementation (Zhu and Li 2017).

This paper aims to assess the market and welfare impact of the TSP in the Chinese cotton market. For this purpose, we develop a partial equilibrium model of the Chinese cotton market with regional coverage and linkages with the rest of the world (ROW). The model is then applied to simulate the impact of the national implementation of TSP on market output; prices; trade; welfare of consumers, producers, and taxpayers; as well as overall national welfare. These indicators are then compared to the benchmark where TSP is applied in Xinjiang and DPP in the Inland. To the best of our knowledge, this paper is the first to investigate the impact of a countrywide TSP on the Chinese cotton market with explicit within–country regional differentiation.

CHINA'S TRADE POLICY IN THE COTTON MARKET

The import of cotton in China far exceeds its exports and is subject to the tariff-rate-quota (TRQ) regime (Pan, Hudson, and Ethridge 2010). In Figure 1, import demand (*ID*) and export supply (ES_{FT}) under free trade illustrate the initial trade equilibrium. Firstly, the World Trade Organization (WTO)–related TRQ ensures that the in–quota tariff rate does not exceed 1 percent for the first 894,000 t of imports in each calendar year, turning the export supply upward as is shown by its first segment of export supply after policy intervention (ES_{PI}). Furthermore, the government, based on

Figure 1. The impact of China's cotton trade policy on the world's export supply curve
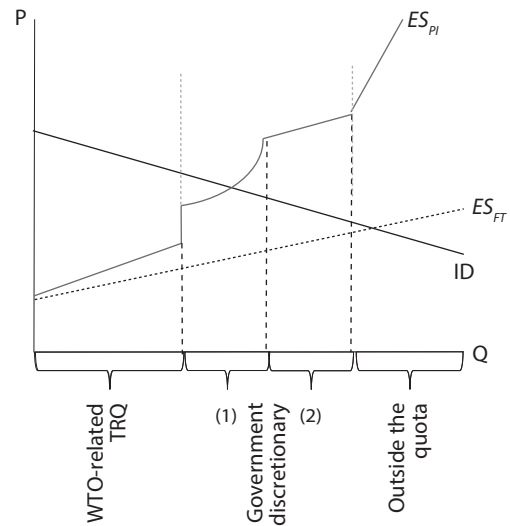
Source: Authors' illustration

the import demand condition, releases additional quota at its discretion. For example, from 2004 to 2014, the discretionary quota varied from 0.4 to 2.7 million tons and no additional quota has been released from 2015 to 2017 (Richey and Nguema 2019). Within the discretionary quota range, the tariff rent is calculated as shown below (CTCSC 2016):

$$t = 9.337/CIF + 0.0277CIF - 1, \qquad (1)$$

when the cost-insurance-freight (CIF) price of imported cotton is lower than CNY 15 (USD 2.17 in 2016) per kg. This shifts ES_{PI} and lets it increase non-linearly as shown by the second segment of ES_{PI}. When the CIF price is higher than CNY 15 per kilogram, a tariff of CNY 0.57 (USD 0.08 in 2016) per kilogram is imposed, forming the third segment of ES_{PI}. The purpose of this sliding scale tariff is to ensure that domestic producers are protected from fluctuations in international market prices. Once the government quota is filled, the imports are allowed at the tariff rate of 40 percent (GACC 2014) giving a rise to the fourth segment of ES_{PI}. Note that ES_{PI} can intersect with *ID* in any segments.

Apart from tariff and quota policies, the ways in which the quota is allocated to different importers has important welfare implications. In China, the National Development and Reform Commission and the Ministry of Commerce govern the quota allocation. The quota application process is quite onerous hence many potential importers are excluded from the onset (Nigh 2013). After ensuring that state trading enterprises receive 33 percent of quotas, the remainder is allocated based on the number of qualified applicants, their historical import level, production capacity, and other relevant information (NDRC and MOFCOM 2017). The quotas are typically allocated to cotton millers and/or traders. However, due to data limitations, this study does not consider administration cost of quota allocation in the welfare analysis.

THEORETICAL ANALYSIS OF CHANGE FROM DPP TO TSP

In this study, the impact of a nationwide TSP is seen as a policy shift from DPP. The market and welfare impact of this policy would be best represented in a single graph. However, the structure of supply, particularly when producer prices vary under the two policies, makes it difficult to illustrate. Furthermore, different results are expected depending on the level of target prices. To avoid this complexity while at the same time taking into account the equivalent comparative static impacts, we first illustrate the policy shift of DPP removal in the Inland, and subsequently, we introduce TSP in an undistorted domestic market.

Market and welfare impacts of the policy switch are illustrated in Figures 2 and 3. In panel "a" of each figure, the equilibrium price P_0 and quantity Q_0 are obtained when the demand (D) and Supply (S) curves intersect in the absence of any domestic intervention policy. In panel "b" of these figures, the intersection of ID and ES defines the import price at which the import quantity QM is determined, which is equal to the difference between the demand and supply quantities, QD and QS, at market price PM.

Referring to Figure 2, direct subsidy payment (s) shifts the supply to S', and import demand to ID', leading to a new market price PM'. Consumers pay the new market price P'_M, and demand a new quantity QD'; producers receive $PS' = PM' + s$ and supply the larger quantity QS'. While both demand and supply quantities increase, the import demand decreases to $QM' = QD' - QS'$. As a consequence, the government pays the subsidy of $QS' * s$, but receives the tariff revenues from the import of QM'. Denoting the symbol

Figure 2. Impacts of DPP relative to no policy intervention on the domestic market
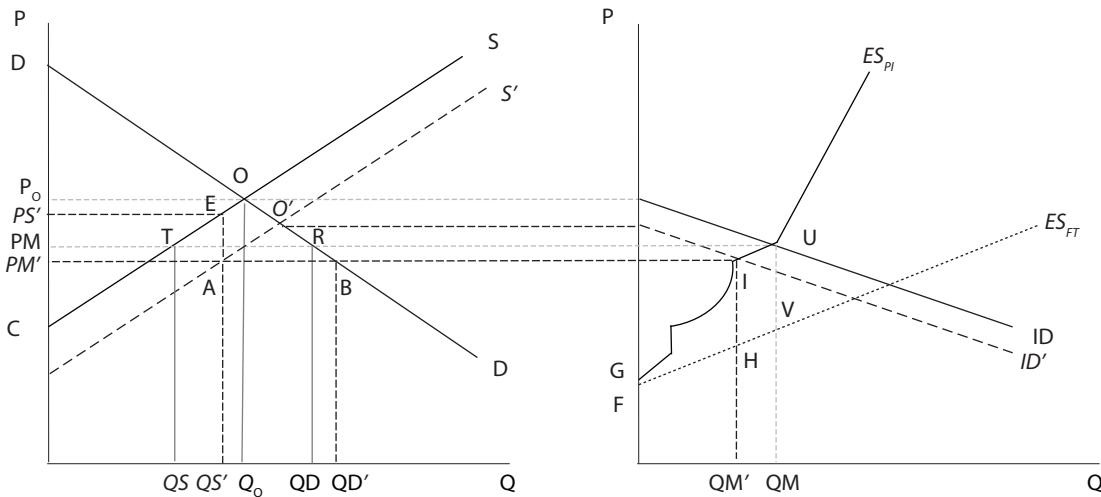
Source: Authors' illustration

Figure 3. Impacts of TSP relative to no policy intervention on the domestic market
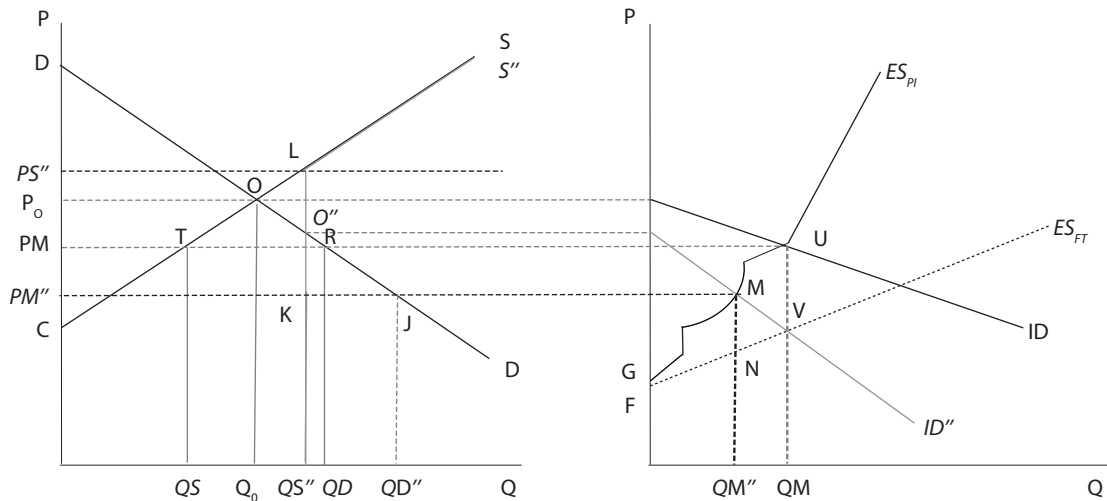
Source: Authors' illustration

Table 1. Welfare changes of various interest groups under DPP and TSP

	Cotton Policy	Consumer Surplus	Producer Surplus	Subsidy Expenditure	Tariff Revenue
(1)	Shift from DPP to no price support (Figure 2)	$-\overline{PM\,R\,B\,PM'}$	$-\overline{PS'\ E\,T\,PM}$	$-\overline{PS'\ E\,A\,PM'}$	$-\overline{I\,U\,V\,H}$
(2)	Shift from no price support to TSP (Figure 3)	$+\overline{PM\,R\,J\,PM''}$	$+\overline{PM\,T\,L\,PS''}$	$+\overline{PS''L\,K\,PM''}$	$-\overline{M\,U\,V\,N}$
(3)	Shift from DPP to TSP (Figures 2 and 3)	(2) ∓ (1)	(2) ∓ (1)	(2) ∓ (1)	(2) ∓ (1)

Source: Authors' compilation

"Δ" as a difference operator, changes in consumer surplus (*CS*) and producer surplus (*PS*) are $\Delta CS = \overline{PM\,R\ B\,PM'}$ and $\Delta PS = \overline{PS'\ \ E\,T\,PM}$, respectively. See Table 1 for more details on other components of welfare change. Conside ring that the DPP is already in place in the Inland, the full removal of the policy generates the same impacts in the same magnitude but with opposite sign.

Subsequently, the impact of implementing a target price of *PS"* is illustrated in Figure 3. Such a policy shifts the supply curve to *S"* such that it is now vertical at supply quantity *QS"* associated with the target price. For prices above the target price, the curve has the same shape as the initial supply curve. The import quantity initially decreases by $QS'' - QS$ and import demand curve shifts to *ID"*, a line that intersects with ES and determines new

import and/or market price *PM"*, which is lower than the initial price (*PM*). At the new market price *PM"*, demand quantity increases to *QD"*, and domestic supply quantity is *QS"*. The difference between *QD"* and *QS"* is the new import quantity after considering adjustments in the world trade market. As a consequence, the government pays a subsidy of (*PS" − PM"*) multiplied by *QS"*, but also receives the revenues from its trade policy, and the changes in CS and PS are $\Delta CS = \overline{PM\,R\,J\,PM}''$, and $\Delta PS = \overline{PM\,T\,L\,PS}''$, respectively (Table 1).

As evident from the analysis above, one expects different impacts (both in magnitude and in direction) associated with removing DPP compared to introducing TSP. The impacts also greatly depend on the trade situation (i.e., on the point at which the import demand curve intersects

the supply curve). The complexity further increases when domestic trade between two regions (i.e. Xinjiang and Inland) is considered as a reflection of different cotton policies in the two regions. Furthermore, while in the above analysis we consider linear relationships for the sake of simplicity, this is likely different in reality. Hence, the next section develops a modeling framework, considering the above-mentioned complexities.

MODELING FRAMEWORK

Econometric and equilibrium-based models are the two widely used approaches in analyzing the impact of domestic agricultural policies. While econometric models are reliable tools to empirically estimate the impact of policy changes, these models require a substantial amount of detailed data across time and/or cross-sections and do not always explicitly take into consideration all the interlinkages of consumption, production, and trade. On the other hand, equilibrium-based models including both computable general equilibrium (CGE) and partial equilibrium (PE) models typically require single year data and capture inter-linkages between markets explicitly, and therefore are preferable tools when the data is limited, and/or the linkages are considered for a simultaneous policy impact analysis (Jafari and Othman 2016; Jafari et al. 2017).

CGE models consider all the economic sectors and their linkages simultaneously and are well suited when the sector under policy reform has strong linkages with the rest of the economy. Since the share of cotton in China is only about 1.5 percent of total value of agricultural output (FAO 2013), we consider PE suitable for our case. Application of PE models in the appraisal of cotton policies can be found in Poonyth et al. (2004) and Pan et al. (2006a and 2006b), among others. Poonyth et al. (2004) used the agricultural trade policy simulation model (ATPSM) to evaluate the market and welfare impact of removing domestic subsidies as well as tariffs in both subsidizing and non-subsidizing countries worldwide. Pan et al. (2006a) and Pan et al. (2006b) used the PE model

of the world fiber market to analyze the worldwide impact of eliminating domestic subsidy and tariffs in the world cotton market, and the U.S. cotton subsidy programs, respectively.[3] Consequently, this study also develops and employs a PE approach to simulate the impact of a policy change in the cotton market. Our model differs from ATPSM and the model of the world fiber market in the way it considers the regional differentiation of cotton market in China, and this is important for our analysis as the cotton subsidy policy in China is regionally differentiated. In contrast to ATPSM, our model is a single commodity and single country model but it considers the linkages with ROW. In contrast to the model of the world fiber market, our model does not explicitly consider the linkages of the cotton market to input markets (e.g., capital), competing fibers (e.g., polyester), and its downstream markets (e.g., textiles). Nonetheless, we perform sensitivity analysis on the supply and demand side parameters of our model to assess the importance of supply and demand side determinants.

Conceptual Representation of China's Cotton Market

For the purpose of our analysis, we divide the world into two regions: China and ROW, with China being comprised of two sub-regions, Xinjiang and the Inland. The sub-regional delineation is based on the difference in cotton policy in the two sub-regions. Supply and demand side interactions between the two sub-regions in China, as well as between China and ROW, are depicted in Figure 4.

The Armington assumption governs the product quality differentiation between China and ROW as well as between the two sub-regions. However, we do not account for differentiation across exporting countries, which is a limitation of this analysis. As shown in the top demand nest, China's total cotton demand is an Armington composite of the aggregate demand

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[3] See also Pan et al. (2007) for an application of the model of world fiber market.

Figure 4. Graphical representation of China's cotton market model
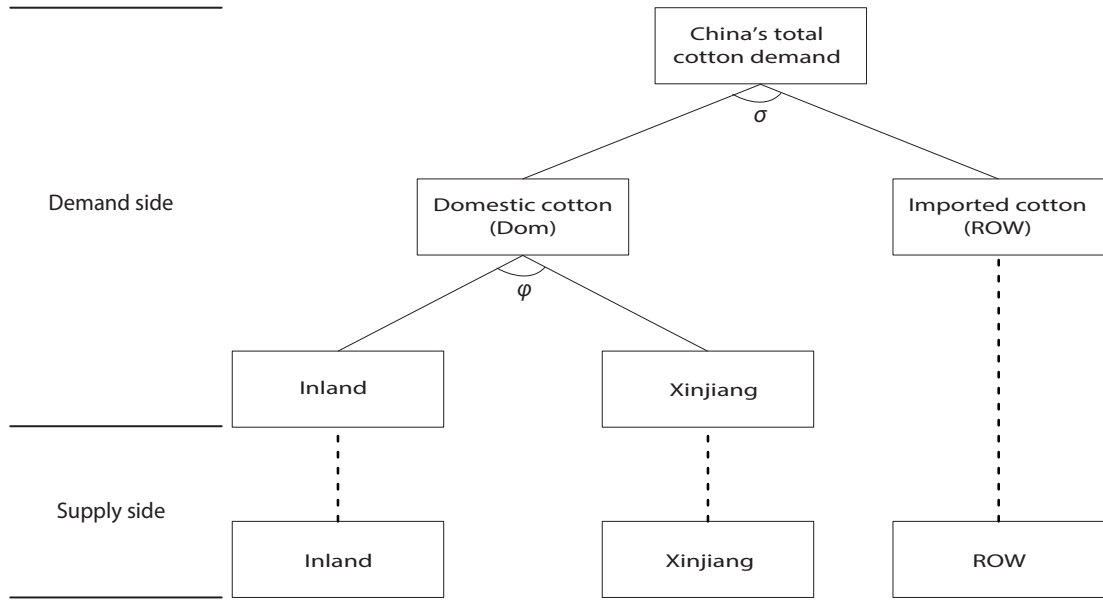
Source: Authors' illustration
Note: Dotted lines represent the market clearing conditions.

for domestically produced cotton and import demands; and substitution between the two sources is governed by the Armington elasticity σ (Armington 1969). In the lower demand nest, the aggregate demand for domestically produced cotton is also an Armington composite of demand for cotton produced in sub-regions, and the Armington elasticity of φ governs the substitution possibilities between the two.

The link between the supply and demand from each market is provided through market clearing conditions.

Mathematical Model

This section puts the conceptual framework into mathematical equations structured by demand and supply blocks, domestic and trade policy measures, and market clearing.

Demand block

Consumers obtain their utility (U) from their total consumption (QD), which is modeled as a constant elasticity of substitution (CES) function of demand for domestically produced cotton (QD_{Dom}) and demand for imported cotton

from ROW (QD_{ROW}) (Equation 2). At the second level of the preference structure, the total demand for domestically produced cotton (QD_{Dom}) is modeled as a CES function of demand for cotton produced in the Inland (QD_{Inl}) and demand for cotton produced in Xinjiang (QD_{Xin}) (Equation 3).

$$U \equiv QD = \left(\alpha_{Dom} QD_{Dom}^{\frac{\sigma-1}{\sigma}} + \alpha_{ROW} QD_{ROW}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, (2)$$

$$QD_{Dom} = \left(\alpha_{Inl} QD_{Inl}^{\frac{\varphi-1}{\varphi}} + \alpha_{Xin} QD_{Xin}^{\frac{\varphi-1}{\varphi}} \right)^{\frac{\varphi}{\varphi-1}}, \quad (3)$$

Parameters α_{Dom} and α_{ROW} represent the preference weight on domestic versus imported good, and parameters α_{Inl} and α_{Xin} represent the preference weight of cotton from the Inland and Xinjiang. The notation σ refers to the elasticity of substitution between domestic and imported cotton, and φ refers to the elasticity of substitution between cotton from the two sub-regions.

The aggregate demand from different sources s, i.e. demand for domestic and imported cotton is obtained by maximizing Equation 2 conditional on aggregate commodity expenditure, resulting in the following demand functions:

$$QD_s = \left[\frac{\alpha_s}{PD_s(1+t_s)}\right]^\sigma PD^\sigma QD, \, s = \text{Dom, ROW}, \quad (4, 5)$$

where PD_s refers to the offered price from each source gross of import tax t_s (for domestic cotton, $t_{Dom} = 0$; for imported cotton, $t_{ROW} \neq 0$). The variable PD is the price index of Armington composite good (QD) and it is defined as:

$$PD = \left(\sum_s \alpha_s^\sigma (PD_s(1+t_s))^{1-\sigma}\right)^{\frac{1}{1-\sigma}}, \quad (6)$$

and governs the substitution between the demand for the differentiated products, i.e. product produced domestically and imported product.

The optimal sourcing of the demand for cotton produced in different sub-regions r in China is obtained by maximizing Equation 3, conditional on composite expending on domestic cotton.

$$QD_r = \left[\frac{\alpha_r}{PD_r}\right]^\varphi PD_{Dom}{}^\varphi QD_{Dom}, \, r = \text{Inl, Xin}, \quad (7, 8)$$

where PD_r refers to consumer price in each sub-region. The price index for domestic demand PD_{Dom} is defined as:

$$PD_{Dom} = \left(\sum_r \alpha_r^\varphi (PD_r)^{1-\varphi}\right)^{\frac{1}{1-\varphi}}, \quad (9)$$

and governs the substitution between the demand for the differentiated products produced in each sub-region.

Considering Equations 4 and 5, the value of QD should be determined. Building on Francois and Reinert (1998), we determine the value of QD based on the following constant elasticity demand function:

$$QD = k * (PD)^\varepsilon, \quad (10)$$

where the constant k scales demand, and ε refers to the demand elasticity.

Overall, on the demand side, the substitution between the domestic and imported cotton is governed by Equation 6 that defines PD.

The value of PD in turn defines QD in Equation 10. Both PD and QD simultaneously determine QD_s in equations 4 and 5. The substitution between the sub-regional demands is governed by Equation 9 that defines PD_{Dom}. This variable, together with QD_{Dom} determined in Equation 4 and 5, defines QD_r. In order to have a solution for Equations 4 through 10, the variables PD_{ROW} and PD_r need to be determined. This is achieved by equalizing the demand equations with supply equations discussed in subsequent parts of the model.

Supply block

Producers maximize profit with respect to a given production technology and prices resulting in the following supply equations associated with each sub-region and ROW (Tokarick 2003):

$$QS_r = \lambda_r (PS_r)^{\mu_r}; \, r = \text{Inl, Xin} \quad (11, 12)$$

$$QS_{ROW} = \lambda_{ROW}(PS_{ROW})^{\mu_{ROW}} \quad (13)$$

where variables QS_r and PS_r are sub-regional production supply and price that producers receive. QS_{ROW} refers to ROW's export supply to China and PS_{ROW} is the import price. The constant term λ scales supply quantities and μ refers to the respective price elasticity of supply.

Domestic and trade policy measures

This section links the endogenous prices of the model to the exogenous domestic and trade policies. The link between producer and consumer prices in each sub-region is provided as:

$$PS_r = PD_r(1 + s_r), \quad (14, 15)$$

where

$$\begin{cases} s_r = (0.14/PD_r) \text{, under DPP;} \\ s_r = (1.33 - PD_r)/PD_r \text{, under the TSP, if } 1.33 > PD_r; \\ s_r = 0 \text{, under the TSP, if } 1.33 < PD_r. \end{cases}$$

Here, the notation refers to the subsidy measure under either DPP or TSP. It should be noted that the coefficient 0.14 is from the DPP system,

reflecting the subsidy of 0.14 per unit price. The coefficient 1.33 in TSP shows that target price is set at the price that is 33 percent higher than market price in Xinjiang. Both coefficients are calibrated based on the data of 2016.

Trade policy measures linking the import and domestic prices are represented as follows:

$$PD_{ROW} = PS_{ROW} (1 + t_{ROW}),$$

$$t_{ROW} = 0.01, \text{ if } 0 < QD_{ROW} < 894{,}000; \quad (16)$$

$$t_{ROW} = 0.4 - (\frac{894{,}000*0.39}{QD_{ROW}}), \text{ if } QD_{ROW} > 894{,}000.$$

For the first 894,000 t of imported cotton as determined by the WTO-related TRQ, the ad-valorem tariff rate of 1 percent is applied. Our review of cotton policy in China reveals that the discretionary government-related TRQ measure did not change from 2015 to 2017, and only the tariff rate of 40 percent is applied for the imports beyond the quota allocated based on WTO-related TRQ. Removal of government discretionary quota is due to an increase in cotton supply and stockpiling of cotton collected from 2011 to 2013 when the price floor was in place. Accordingly, we calculated

the average tariff rate[4] of $0.4 - (\dfrac{894{,}000 * 0.39}{QD_{ROW}})$,

which is considered for all import demand when it exceeds WTO-related TRQ.

Market clearing

In order to ensure the zero trade balance condition (i.e., quantity of imports demanded = quantity of ROW exports supplied) holds and that total quantity demanded in each sub-region is equal to the total quantity supplied (domestic production plus imports), the following market clearing conditions are defined. Equation 17 ensures that China's demand for imported cotton

from the ROW (QD_{ROW}) equals total export supply from ROW (QS_{ROW}). Equation 18 and 19 ensure that the total demand for cotton produced in each sub-region (QD_r), which includes the domestic demand in the sub-region and demand for the sub-region's net exports (i.e., sold outside of the sub-region),[5] is equal to the sub-regional production supply (QS_r).

$$QD_{ROW} = QS_{ROW} \quad (17)$$

$$QD_r = QS_r \quad (18, 19)$$

Finally, equations 4 through 19 provide the partial equilibrium framework consisting of 16 equations and 16 endogenous variables.

Data

This section discusses the value assigned to the model parameters, i.e., elasticities, share parameters, and scale parameters of supply and demand, representing the snapshot of the Chinese cotton market in 2016. In this study, we rely on elasticity values obtained from the literature. The share and scale parameters of supply and demand are calibrated based on the available data and the structure of the model.

Elasticities

Table 2 provides the summary of elasticity values obtained from previous studies. The upper-level Armington elasticity reflects the degree of substitutability between domestic and imported cotton. The global trade analysis project (GTAP) 9 database considers the value of this elasticity equal to 5 for the sector "plant-based fibers" in China (Aguiar, Narayanan, and McDougall 2016). We assigned this value to reflect the substitutability

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[4] Average tariff rate $= \dfrac{(894{,}000*0.01) + 0.4*(QD_{ROW} - 894{,}000)}{QD_{ROW}}$

$= 0.4 - \dfrac{894{,}000*0.39}{QD_{ROW}}$, if $QD_{ROW} > 894{,}000$.

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[5] Note that we have not split the total sub-regional demand to demand for domestically produced cotton and net export demand in each sub-region. Trade between the sub-regions occurs through the impact of policy change on the relative price of each sub-region (PD_r) to the total domestic aggregate price (PD_{Dom}). Furthermore, note that the possibility of a sub-region to be a net importer is captured in the model where the net export value for that sub-region could be negative.

Table 2. Values of elasticities

Elasticity	Value	Sources
Substitution elasticity of domestic and imported cotton (σ)	5	GTAP database
Substitution elasticity of demand from different sub-regions (φ)	10	Based on GTAP database using the assumption in Caron, Rausch, and Winchester (2015, 17), McDaniel and Balistreri (2003, 11)
Price elasticity of demand for cotton in China (ε)	−1	Poonyth et al. (2004, 34)
Supply price elasticity of cotton in the Inland (μ_{Inl})	1.2	Poonyth et al. (2004, 34)
Supply price elasticity of cotton in Xinjiang (μ_{ROW})	1.2	Poonyth et al. (2004, 34)
Export supply elasticity of cotton to China	1.5	Tokarick (2003, 19)

of domestic and imported cotton in China following Hertel et al. (2007). It is common in partial and general equilibrium studies to set the Armington elasticity at the lower nest, φ, representing the degree of substitutability between the two sub-regions as twice high as the upper-level Armington elasticity (McDaniel and Balistreri 2003; Caron, Rausch, and Winchester 2015), therefore the value of $\varphi = 2\sigma = 10$ is assigned to this parameter.

The demand elasticity (Equation 10) represents China's total demand response to the aggregate price index. We use the corresponding value of this parameter of -1.0 for cotton products according to the ATPSM. This elasticity is also used by several authors studying the cotton market (Poonyth et al. 2004). The ATPSM also provides the long-run price elasticity of supply for China, equal to 1.2, which is used in several studies of the cotton market (Poonyth et al. 2004; Gadanakis, Baourakis, and Clapan 2007). We assign this value for each of the two sub-regions in China. As for the cotton export supply elasticity of ROW, we rely on Tokarick (2003) who guesstimated a value of 1.5 for this parameter.

Share parameters

Share parameters in Equations 4 and 5 are calibrated based on the information on prices and quantities in 2016, and the obtained values of the substitution elasticities from literature. Following Zhang and Verikios (2006), we calibrate the share parameters for domestic and imported products as follows.

$$\alpha_{Dom} = \frac{PD_{Dom} * QD_{Dom}^{\frac{1}{\sigma}}}{PD_{Dom} * QD_{Dom}^{\frac{1}{\sigma}} + PD_{ROW} * QD_{ROW}^{\frac{1}{\sigma}}} \quad (20)$$

$$\alpha_{ROW} = 1 - \alpha_{Dom} \quad (21)$$

The information on cotton price and quantities in 2016 is obtained from the CCA (2017). A similar calibration approach is utilized to obtain share parameters in Equation 7 and Equation 8. Table 3 summarizes value of share parameters in the model.

Table 3. Values of share parameters

Notation	Description	Value
α_{Dom}	Share parameter of Dom	0.745
α_{Row}	Share parameter of ROW	0.255
α_{Inl}	Share parameter of the Inland	0.445
α_{Xin}	Share parameter of Xinjiang	0.555

Source: Calibration based on the model structure and initial data

Scale parameters of demand and supply

Lastly, values of the scale parameters in Equations 10 through 13 are calibrated based on the available information for demand and supply price and quantities as well as elasticity values. The calibration is based on solving these equations for the scale parameters as a function of pertinent price, quantity, and elasticity values (Francois and Reinert 1998; Tokarick 2003).

MODEL APPLICATION, SIMULATION RESULTS, AND DISCUSSIONS

Before running the counterfactual scenario, it is necessary to calibrate the model. The result of the calibration shows that the model can replicate the benchmark data well. The third column of Table 4 indicates the value of endogenous variables in the benchmark. We use the nonlinear programming (NLP) solver in general algebraic modelling system (GAMS) environment to run our policy scenarios. Upon validation of the model, we simulate the market and welfare impact of a policy shift from DPP to TSP in the Inland (hereafter, the "scenario"). Lastly, sensitivity analysis is performed on the magnitude of policy shock and on the value of important parameters in the model.

Market Impacts

The impact of implementing TSP in the Inland instead of DPP on variables of interest is presented in Table 4. The last column shows the percentage change from the benchmark (DPP regime). The implementation of the TSP in the Inland leads to a 31 percent higher producer price, which in turn encourages Inland cotton producers to increase production supply by more than 27 percent and a market price decrease in the Inland by around 7 percent. The price effect shifts demand from Xinjiang cotton to Inland cotton leading to a decrease in market price of Xinjiang by 4.9 percent.

Total production of domestic cotton increases by 6.91 percent, which is accompanied by a decrease of 5.51 percent in the Chinese domestic market/consumer price and a reduction of import demand by 5.6 percent. The reduction in import demand does not fully compensate the increase in demand for the domestic product and, therefore, total demand increases by 6.39 percent.

Overall, the shift of the policy decreases the market price for domestically produced cotton, increases domestic supply and demand, and reduces imported cotton, with an overall increase in total demand.

Welfare Impact Analysis

With the market (output, price, and trade) effects determined, the welfare change can be calculated accordingly. As shown in Table 5, if TSP replaces DDP in the Inland, consumer surplus in China increases slightly since this policy shift leads to a price decrease and demand increase in the country. Producer surplus is projected to increase significantly due to the increase in the price farmers receive and the quantity they sell in the market. Our results also show that producers in Xinjiang would experience a small decrease (3.4%) in their welfare (not shown in the table). Nonetheless, a

Table 4. Simulation results for TSP implementation in the inland in place of DPP

Variables	Description	Benchmark	Scenario	Change (%)
PS_{Inl}	Supply price index of Inland cotton	1.01	1.33	31.68
QS_{Inl}	Supply of Inland's cotton (1,000 t)	2,341	2,977	27.17
PD_{Inl}	Demand price index for Inland's cotton	0.87	0.81	−6.90
PD_{Xin}	Demand price index for Xinjiang's cotton	1.02	0.97	−4.90
QD_{Xin}	Supply of Xinjiang's cotton (1,000 t)	4,516	4,428	−1.95
QD_{Dom}	Demand for domestic cotton (1,000 t)	3,531	3,775	6.91
PD_{Dom}	Demand price index for domestic cotton	1.886	1.782	−5.51
QD_{ROW}	Demand of imported cotton (1,000 t)	910	859	−5.60
PD_{ROW}	Demand price index for imported cotton	0.84	0.81	−3.57
QD_{China}	Total demand (1,000 t)	7,767	8,263	6.39

Source: Simulation results
Note: Prices are normalized relative to the Xinjiang demand price in benchmark.

Table 5. Welfare of different interest groups and their changes (billion CNY)

Interest Groups	Benchmark	Scenario	Change (%)
Consumer surplus (A)	5,173	5,179	0.12
Producer surplus (B)	516	586	13.57
Subsidy expenditure (C)	240	436	81.67
Tariff revenue (D)	0.18	0.10	−44.44
Total welfare (A+B-C+D)	5,449.18	5,329.10	−2.20

Source: Simulation results

Note: CNY 1 billion is equivalent to USD 14.9 million in April 2019.

significant increase (54.2%) in producer surplus in the Inland contributes to increase in the average well-being of producers in China.

Government's expenditure would increase substantially, mainly due to the considerable rise in subsidizing the Inland (by a factor of 3.7). Thus, the subsidy for the Inland would comprise a much larger share of total expenditure of the government. Meanwhile, as import demand goes down, tariff revenues would shrink to a large extent. Considering both increases in subsidy payment and reduction in tariff revenues, the net government expenditure increases considerably (by 80%, not shown in the table).

The result shows a small reduction in overall welfare. It suggests that the nation would be marginally worse off if the policy shift would happen. This is because the reduction in government revenue does not compensate for increase in producer and consumer surplus. In other words, this policy shift would sacrifice government's revenue but benefit consumers and cotton farmers.

Sensitivity Analysis

In this section, we first perform additional policy scenarios where the target price varies in both sub-regions. Further, we perform the sensitivity analysis on the important parameters of the model when the scenario is considered. Tables 6 and 7 summarize the detailed results, but we only discuss the points with important policy implications.

Table 6. Market effects (%) due to different target prices, supply elasticities, and Armington elasticities

	Inland		Xinjiang		Domestic Market		Import	
	Supply/ demand	Consumer price	Supply/ demand	Consumer/ price	Supply/ demand	Consumer price	Supply/ demand	Consumer price
Target price								
1.33	27.17	−6.90	−1.95	−4.90	6.91	−5.51	−5.60	−3.57
1.25	22.58	−4.11	−5.46	−1.66	3.07	−2.49	−2.95	−1.90
1.20	19.66	−2.17	−7.72	0.39	0.61	−0.47	−1.16	−0.71
1.15	16.68	0.00	−10.01	2.54	−1.88	1.69	0.73	0.59
1.14	16.07	0.45	−10.48	3.03	−2.39	2.17	1.13	0.83
Supply elasticities								
1.2	27.17	−6.90	−1.95	−4.90	6.91	−5.51	−5.60	−3.57
1.5	31.97	−8.19	−2.75	−5.34	7.97	−6.31	−6.51	−4.39
2.0	38.81	−9.49	−4.32	−6.04	9.36	−7.34	−7.35	−4.97
2.5	44.53	−10.55	−6.06	−6.64	10.45	−8.15	−8.01	−5.42
Armington elasticities								
2	23.88	−9.17	−0.81	−4.08	6.59	−5.75	−2.51	−1.67
3	25.54	−8.23	−1.40	−4.39	6.74	−5.63	−4.03	−2.74

Table 6 continued

	Inland		Xinjiang		Domestic Market		Import	
	Supply/ demand	Consumer price	Supply/ demand	Consumer/ price	Supply/ demand	Consumer price	Supply/ demand	Consumer price
4	26.56	−7.55	−1.72	−4.59	6.86	−5.62	−5.10	−3.45
5	27.17	−6.90	−1.95	−4.90	6.91	−5.51	−5.60	−3.57
6	27.62	−6.86	−2.08	−4.79	6.97	−5.51	−6.15	−4.16
7	28.01	−6.63	−2.18	−4.90	7.03	−5.51	−6.64	−4.51
8	28.20	−6.52	−2.27	−4.90	7.03	−5.45	−6.73	−4.52

Source: Simulation results

Table 7. Welfare changes (%) due to different target prices, supply elasticities, and Armington elasticities

	Consumer Surplus	Producer Surplus			Government Expenditure			Total Welfare
		Inland	Xinjiang	Total	Subsidy expenditure	Tariff revenue	Net	
Target price								
1.33	0	0	0	0	0	0	0	0
1.25	−0.06	−6.48	−5.29	−5.77	−10.23	4.75	−10.26	−0.04
1.20	−0.10	−10.53	−9.39	−9.85	−16.70	32.43	−16.81	−0.07
1.15	−0.14	−14.57	−13.48	−13.92	−23.31	118.28	−23.62	−0.10
1.14	−0.15	−15.38	−14.30	−14.73	−24.70	136.25	−25.06	−0.11
Supply elasticities								
1.2	0	0	0	0	0	0	0	0
1.5	0.00	8.94	−3.12	1.69	1.52	−0.61	1.52	0.01
2.0	0.00	23.96	−10.55	3.21	3.35	−1.14	3.36	0.01
2.5	0.00	39.31	−17.73	5.02	4.83	−1.42	4.84	0.02
Armington elasticities								
2	0.09	−4.36	1.54	−0.80	−0.76	4.34	−0.78	0.89
3	0.04	−2.38	0.74	−0.49	−0.35	2.25	−0.36	0.34
4	0.02	−0.95	0.29	−0.20	0.06	1.29	0.06	0.12
5	0	0	0	0	0	0	0	0
6	−0.01	0.66	−0.35	0.05	0.21	−0.57	0.21	−0.01
7	−0.02	1.14	−0.35	0.24	0.39	−0.81	0.40	−0.02
8	−0.02	1.53	−0.47	0.32	0.37	−1.54	0.37	−0.02

Source: Simulation results

Varying the level of target prices

The scenario simulated the impact of a switch from DPP to TSP in the Inland, while Xinjiang continues with current TSP. In this scenario, the target price of 33 percent above the market price is implemented in the Inland, similar to that in Xinjiang. However, it is possible that the government adjusts target price in the future since the target price from 2017 onward is set every three years (NDRC and MOF 2017). Sensitivity analysis of the lower level target prices is conducted because the significant increase in the government expenditure as simulated in the scenario might push the government to reduce the target price.

This is also relevant when China might not want to increase the amount of coupled support as the WTO discourages it. For these reasons, a TSP level equivalent of DPP in the Inland, ensuring that the government support does not increase, is also considered in our simulation.

As target prices in both sub-regions decrease from 1.33 (target level, see Equation 14 and 15) to 1.14 (equivalent price under DPP), cotton farmers would seem to be less motivated. We found the coefficient of 1.2 as a turning point for average consumer price in China: prices in each sub-region initially experience a decrease until this target level but thereafter, an increase. The same happens to import demand/supply and import price at this threshold. This indicates that the target prices in the range of 33 percent to 20 percent above the market price would warrant the government objective of increase in domestic supply and reduction in imports, while national welfare only changes marginally. This means that 120 percent of the market price could stand for the average nationwide price received by cotton farmers under current policy arrangement, i.e., TSP in Xinjiang and DPP in the Inland.

In terms of welfare change, with the target price decreasing, producer surplus in both sub-regions is projected to decrease significantly. Meanwhile, changes in total welfare are not considerable. But it substantially reduces the government financial burden on subsidizing the cotton industry and also increases government revenue due to the increase in imports, which in turn results in significant decrease in government net expenses. Nonetheless, if the government gives more weight to the producers than general taxpayers, the target price that is more toward the upper-level support could be implemented; otherwise, the target price should be reduced, but not less than the lower target price level of 20 percent above market price.

Sensitivity analysis on parameters of the model

Sensitivity analysis on parameters of the model reveals how changes in assumptions of an economic model affect its predictions, and it helps in drawing policy implications from the results in the presence of uncertainty (Gurrea and Neuberger 2010). Important parameters in our analysis are the supply elasticity of domestic cotton and the Armington elasticities. Supply elasticity of domestic cotton could reflect not only farmers' response to price changes but also government intention to release some of the stocks of cotton. Sensitivity analysis on this parameter is important since China possessed more than 60 percent of the world cotton stocks in 2015 (Anderson and Clever 2017). We also investigate the robustness of our result with varying level of Armington elasticities, indicating the degree by which domestic and foreign cotton are differentiated, and differentiated across regions and sub-regions. The two Armington elasticities in this paper have important implications since they represent the substitutability between domestically produced and imported cotton, and of the cotton produced across regions and sub-regions.

With the supply elasticity raised from 1.2 to 2.5 (reflecting a situation where government is less willing to release cotton stocks, or where farmers react more to the supply price), the policy shift from benchmark to the scenario leads to the results in the same direction but in higher magnitudes. This is especially true for the cotton supply in the Inland, which reacts much more sensitively than that of Xinjiang. The same happens to producer surplus in these two sub-regions, as we can see a more significant increase in producer surplus in the Inland than Xinjiang. In total, a higher supply elasticity of domestic cotton would lead to higher domestic cotton supply. This indicates that policy measures and institutional arrangments that would make farmers more flexible in response to market prices and the release of cotton stock outside domestic market could help government in achieving its goal in increasing production and reducing imports.

We further perform the sensitivity analysis on the upper-level Armington elasticity but allow the lower-nest elasticity to remain twice as high as the upper one. Higher substitution between domestically produced cotton and imported cotton ($\sigma > 5$) and, therefore, between the domestically produced cotton of different sub-regions ($\varphi > 10$)

results in further increase in domestic supply, further decrease in domestic prices, and therefore, a greater decrease in imports. The lower substitution elasticities have the reverse impacts. Such results indicate that the impact of implementing TSP in the Inland is dependent on the differentiability of the products of different sources. If the products are more homogenous across regions and sub-regions, the impacts are more pronounced. Accordingly, the appropriate policy measure should be taken to ensure that quality of cotton produced as a result of production support policies will not deterioriate the quality of the product.

CONCLUSION AND POLICY IMPLICATION

This paper aims to quantify the impacts of a nationwide TSP on market output and prices, imports, as well as welfare on both the sub-regional and the national levels. For this purpose, we develop and apply a partial equilibrium model of the Chinese cotton market with sub-regional coverage and linkages to the rest of the world to quantify the impact of the policy move from DPP to TSP nationwide on output, prices, welfare of various interest groups at both sub-regional and national levels, and on trade.

Simulation results suggest that the policy shift motivates cotton farmers in the Inland to considerably increase cotton supply (31%), leading to a small reduction (1.95%) in the supply of the competing region of Xinjiang, where the TSP was already applied before. The simultaneous analysis of sub-regional changes suggests that domestic cotton supply increases significantly. Consequently, demand for imported cotton would decrease.

Interesting policy implications were revealed by performing sensitivity analysis on the target price level such as the flexibility of farmers in response to price changes, and on the quality differences of the cotton produced across regions. Our results suggest a lower limit to the target price of 20 percent above market price. Below this, the government's objective to increase self–sufficiency compared to the current policy arrangement is not likely to be achieved. Furthermore, more

profound impacts arise when the government does not release current cotton stocks, as such policy is presumed to decrease the response of farmers to changes in prices. Additionally, our sensitivity analysis on the Armington elasticities reveals that the more differentiated the products are across the regions, the stronger is the impact across sectors. Such results imply that policy measures, which improve the quality of domestic products or prevent their deterioration in quality would better serve the government objectives.

Producers in the Inland are projected to benefit significantly from the TSP but producers in Xinjiang are expected to experience a small loss. Overall producer surplus is expected to increase by 13.5 percent. Government expenditure increases by more than 80 percent, which might push the government to set the target price at a lower level. Although changes in overall welfare are small, there is a clear inverse pattern in the movement of producer surplus and government expenses. While a target price between 120 percent and 133 percent of the market price serves the production and import objectives without having a significant effect on national welfare, the decision on the exact target level very much depends on the relative weights that government gives to producers vis-à-vis general taxpayers. If the well-being of producers has more weight in the social objective function, a target price toward the upper level of the range would better serve government priorities. However, considering that a high target price increases the government financial burden, such a policy might not be sustainable in the long run.

This study sufficiently addresses the welfare and market impact of the move in domestic policy by breaking down the Chinese regions and providing explicit linkages to the rest of the world. However, future studies are warranted to consider the impacts on major cotton exporters such as the USA, India, Australia, and Brazil, as the impacts of the policy shift on these countries could trigger policy responses on their side. Such analysis requires extending the model where these countries are modeled separately.

This study has made reasonable attempts to implicitly consider the intention of the government to change the stock of the cotton through changes in domestic supply elasticities. Future modeling of explicit stock changes may show the dynamic adjustments with potentially important policy implications. In addition, this paper only measures the market welfare change from modeling the output market, but important welfare implications could arise when input markets are explicitly modeled as well, given that inputs are subsidized by the government (Gale 2013; Yu and Jensen 2010). Finally, welfare changes due to non-market factors associated with the use of more inputs such as land, water, and agrochemicals are not considered in this study. Cotton production uses these factors intensively, which could result in certain environmental impacts (Wossink and Denaux 2006; Yilmaz, Akcaoz, and Ozkan 2005) not considered in the study.

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