Journal of Agricultural and Applied Economics, 44,2(May 2012):235–249

Do U.S. Cotton Subsidies Affect Competing Exporters? An Analysis of Import Demand in China

Andrew Muhammad, Lihong McPhail, and James Kiawu

We estimate the demand for imported cotton in China and assess the competitiveness of cotton-exporting countries. Given the assertion that developing countries are negatively affected by U.S. cotton subsidies, our focus is the price competition between the United States and competing exporters (Benin, Burkina Faso, Chad, Mali, India, and Uzbekistan). We further project how U.S. programs affect China's imports by country. Results indicate that if U.S. subsidies make other exporting countries worse off, this effect is lessened when global prices respond accordingly. If subsidies are eliminated, China's cotton imports may not fully recover from the temporary spike in global prices.

Key Words: China, cotton, import demand, Rotterdam model, subsidies, United States, West Africa

JEL Classifications: F17, Q11, Q17

Because cotton is one of the principal program crops in the United States, producers are eligible for the following types of government support: direct or decoupled payments, countercyclical payments based on target prices or revenue guarantees, marketing loan benefits, and crop revenue insurance.[1] The United States has also administered other programs such as export credit guarantee programs (GSM-102 and GSM-103), the Supplier Credit Guarantee Program (SCGP), and user marketing certificates (Step-2 payments).[2] It has been argued that these programs significantly impact world markets by depressing world prices through excess production and trade (Alston and Brunke, 2006; Alston, Sumner, and Brunke, 2007; Quirke, 2002).

China is the most important destination market for global cotton exports. Since China's accession to the World Trade Organization in December 2001, its cotton imports increased from 56 million kg in 2001 to 3.6 billion kg by 2006, an increase of over 6,000%. This growth

Andrew Muhammad is a senior research economist, Lihong McPhail is a research economist, and James Kiawu is an outlook economist with the U.S. Department of Agriculture, Economic Research Service, Market and Trade Economics Division, Washington, D.C.

We thank three anonymous reviewers and the editor, Darrell Bosch, for their helpful comments.

[1] See Schmitz, Rossi, and Schmitz (2007) for a description of how these programs specifically apply to the U.S. cotton sector.

[2] Step 2 payments were made to exporters and domestic mills to compensate for their purchase of higher priced U.S. upland cotton. In 2004, a WTO dispute settlement panel found that Step 2 payments and export credit guarantees were inconsistent with WTO commitments. Consequently, the United States terminated Step 2 payments in 2006 and GSM-103 and SCGP in 2008 (Schnepf, 2010).

was further supported by the expiration of the Multi-Fiber Arrangement in January 2005. China is now the leading cotton importer in the world accounting for over one-fourth of world trade (United Nations Commodity Trade Statistics [UN Comtrade] Database, 2011).[3] China has accounted for as much as 50% of total cotton exports from the Cotton-4 (C-4) countries (Benin, Burkina Faso, Chad, and Mali) and as much as 60% from India and Uzbekistan (UN Comtrade, 2011).

The United States is the leading supplier of cotton to China. Consequently, U.S. cotton programs could affect competing exporters in the Chinese market. Alston and Brunke (2006), Alston, Sumner, and Brunke (2007) and Quirke (2002) assert that cotton subsidies in the United States depress world cotton prices resulting in welfare loss for producers in developing countries. This issue is particularly important to the C-4 where the cotton sector represents the largest share of nonoil export receipts in the region with export earnings accounting for more than 3% of the Gross Domestic Product (Hanson, 2007; Jales, 2010).

In this study, we examine the factors that determine China's demand for imported cotton. Of particular interest is the price competition between the United States and competing exporters (Benin, Burkina Faso, Chad, Mali, India, and Uzbekistan) and the impact of U.S. cotton subsidies in the Chinese market. The major suppliers of cotton to China are the United States, India, and Uzbekistan. Although individual C-4 countries are smaller by comparison, their combined share of China's market has been comparable to India and Uzbekistan. In 2010, total cotton imports in China were valued at $5.7 billion, where the United States, India, and Uzbekistan accounted for 35%, 31%, and 12%, respectively. India's share of China's market increased from as low as 4.7% in 2005, whereas the U.S. share decreased from as high as 47.6% in 2008. During the period 2005–2010, imports from the C-4 accounted for as much as 12.2% in 2005 but decreased to 3.8% in 2010 (Table 1).

Our primary objective is to assess the impact of U.S. cotton programs on import demand in China. We begin by estimating the import demand for cotton in China using a source-differentiated framework (Armington, 1969), which is appropriate given the perceived quality differences across countries. Past import demand studies have typically used consumer demand models such as the almost ideal demand system (AIDS) (Deaton and Muellbauer, 1980) and Rotterdam model (Theil, 1980). However, given the intermediate nature of cotton, we model import demand as input demand and use the differential approach to the theory of the firm for the empirical analysis (Laitinen, 1980; Theil, 1977). The empirical model is derived from a two-step profit maximization procedure resulting in a structural system of import demand equations. The system of equations allows for the determination of total import expenditures and source-specific imports. The import demand estimates are used to derive conditional and unconditional demand elasticities, which are used to project how U.S. cotton programs affect cotton demand in China. Given the size of the U.S. cotton sector, a U.S. price shock could ultimately affect global prices. We use a vector autoregression (VAR) procedure to assess the price relationship among the United States, India, Uzbekistan, and the C-4. Import demand simulations are conducted and compared assuming a one-time U.S. price shock and the price relationships derived from the VAR procedure.

Although China is the largest cotton importer and an important destination market for exporting countries, no study has examined China's cotton demand using a source-differentiated framework.[4] Researchers have examined the impact of Bt cotton adoption in China on global cotton trade (Anderson, Valenzuela, and Jackson, 2008; Fang and Babcock, 2003; Frisvold, Reeves, and Tronstad, 2006; Huang et al., 2004). Others

[3] Cotton imports are defined according to the Harmonized Commodity Description and Coding System classification 5201: *cotton, not carded, or combed.*

[4] Mutuc et al. (2011) examined China's cotton imports disaggregated by source but considered only two sources: the United States and the *rest of the world.*

Table 1. Cotton Imports in China and Exporter Market Shares: 2005–2010

Year	Total Imports ($U.S. billion)	Market Shares (%)								
		United States	India	Uzbek.	Benin	Burkina Faso	Chad	Mali	C-4	ROW
2005	3.193	45.9	4.7	11.9	4.0	5.1	0.6	2.5	12.2	25.3
2006	4.868	47.0	15.7	10.1	1.7	4.0	0.6	2.2	8.4	18.7
2007	3.479	46.1	25.0	8.6	2.3	4.5	0.2	0.9	7.9	12.5
2008	3.494	47.6	27.5	7.9	2.4	1.8	0.2	1.6	6.0	11.0
2009	2.114	41.3	21.2	8.3	3.3	5.4	0.2	1.1	10.0	19.1
2010	5.658	35.3	30.7	12.2	1.0	2.1	0.0	0.8	3.8	17.9

Source: World Trade Atlas® database, Global Trade Information Services, Inc.
ROW, rest of the world.

have examined the effects of China's currency policy on global cotton markets (Ge, Wang, and Ahn, 2010; Pan et al., 2007), how the elimination of the Multi-Fiber Agreement affected China's role in global cotton markets (Audet, 2007; Li, Mohanty, and Pan, 2005; MacDonald et al., 2010; Mutuc et al., 2011), and how China's WTO accession affected global cotton trade (Fang and Babcock, 2003; Fuller et al., 2003). A recent study has also considered the global recession and China's cotton supply chain (Xiao, 2010).

The absence of source-differentiated analyses of Chinese cotton demand is not surprising because the growth in China's cotton imports is fairly recent. During the period 1999−2002, China's cotton imports averaged less than $100 million per year. Additionally, source-specific competition was limited in years prior. In 1995, for instance, the United States was the primary supplier of cotton to China accounting for 68% of total imports, whereas India accounted for less than 1%. Our focus on China adds to the existing literature on source-differentiated analysis of cotton markets by Alston et al. (1990), Arnade, Pick, and Vasavada (1994), and Chang and Nguyen (2002), in which they examined cotton demand differentiated by source in such countries as France, Italy, Japan, Taiwan, and Hong Kong.

Import Demand Model

Because cotton is used as an input in fabric production, cotton demand is modeled as firm demand and a production version of the Rotterdam model is used for the analysis. For the underlying theory and model derivation, see Laitinen (1980) and Theil (1977, 1980), and for empirical applications, see Clements and Theil (1978), Davis (1997), Muhammad (2007, 2009), and Washington and Kilmer (2002).

Assume a firm that imports cotton from n countries, which is then used to produce cotton fabric. Further assume that cotton imports and the domestic resources used in production are separable, which implies that the demand for cotton from the ith country can be expressed as a function of the total expenditures on imported cotton and import prices by country (Clements and Theil, 1978). Let q and p denote the import quantity and price, respectively, and i and j the exporting country. Theil (1980, p. 35) shows that for a cost-minimizing firm, the demand for cotton from the ith country can be specified as follows:

$$
\begin{aligned}
f_{it}d(\log q_{it}) &= \theta_i d(\log Q_t) + \sum_{j=1}^{n} \omega_{ij} d\left(\log p_{jt}\right) \\
&+ \alpha_{1i} \sin\left[\frac{2\vartheta}{z}\pi t\right] \\
&+ \alpha_{2i} \cos\left[\frac{2\vartheta}{z}\pi t\right] + \varepsilon_{it}.
\end{aligned} \tag{1}
$$

$f_i = \frac{p_i q_i}{\sum_i p_i q_i}$ is the share of total cotton imports from country i. $d(\log Q_t) = \sum_{i=1}^{n} d(\log q_{it})$ is the Divisia volume index, which is a measure of the change in real aggregate expenditures on cotton imports. $\theta_i = \frac{\partial p_i q_i}{\partial \sum_i p_i q_i}$ is the marginal share of the ith import (expenditure effect), and ω_{ij} is the conditional price effect, which measures the impact of the price in country j on the quantity imported from country i. Following Arnade, Pick, and Gehlhar (2005), the sine and cosine terms are added to account for the seasonality in cotton imports where ϑ is the frequency of the seasonality cycle, equal to one in this instance, and z is the frequency of the data, which is 12 because the data are monthly. θ, ω, and α are parameters to be estimated and ε is a random disturbance term.

Given the theoretical demand properties, adding up, homogeneity, and symmetry, the following parameter restrictions should hold true:

$$\sum\nolimits_{i=1}^{n} \theta_i = 1 \quad \text{and} \quad \sum\nolimits_{i=1}^{n} \omega_{ij} = \sum\nolimits_{i=1}^{n} \alpha_{1i} = \sum\nolimits_{i=1}^{n} \alpha_{2i} = 0 (\text{adding-up});$$

$$\sum\nolimits_{j=1}^{n} \omega_{ij} = 0\ (\text{homogeneity});\ \text{and}$$

$$\omega_{ij} = \omega_{ij}\ (\text{symmetry}).$$

Additionally, the matrix of conditional price effects $\mathbf{\Omega} = [\omega_{ij}]$ should be negative semidefinite (Laitinen, 1980).

Following Theil (1977), the determination of real aggregate expenditures can be expressed by the following Divisia index equation:

$$(2) \quad d(\log Q_t) = \frac{\gamma\psi}{\gamma - \psi}[d(\log p_t^*) - d(\log P_t^{'})] + \mu_t.$$

The variable p^* denotes the output price and $d(\log P')$ is the Frisch import price index where

$$(3) \quad d(\log P_t^{'}) = \sum_{j=1}^{n} \theta_j d(\log p_{jt}).$$

ψ can be interpreted as a measure of cost–function curvature and is derived as

$$\frac{1}{\psi} = 1 + \frac{1}{\gamma^2}\frac{\partial^2 \log C}{\partial(\log Y)^2}.$$

Y is firm output, $C = \sum_{i=1}^{n} p_i q_i$ is total import cost, and γ is the elasticity of cost with respect to output. The term $\gamma\psi/(\gamma - \psi)$ is the Frisch-deflated output price effect and is assumed constant for estimation. μ is a random disturbance term. All other terms and variables are as previously defined. Equations (1) and (2) form a system where equation (1) is the import allocation decision, which describes the change in demand for cotton from country i as a function of real aggregate expenditures and import prices by country; and equation (2) is the determination of real aggregate expenditures where expenditures are a function of the domestic output price deflated by the Frisch import price index.

From equation (1), the conditional demand elasticities are derived. The expenditure elasticity is θ_i/f_i, and the conditional own- ($i = j$) and cross- ($i \neq j$) price elasticity is ω_{ij}/f_i. Additionally, the parameters from equations (1) and (2) can be used to derive unconditional demand elasticities. If we substitute equation (3) for the Frisch import price index in equation (2), and then substitute this into equation (1), we get the demand for an individual import with respect to the output price p^* and import prices p_j:

$$(4) \quad f_i d(\log q_i) = \theta_i \Theta d(\log p^*) - \theta_i \Theta \sum_{j=1}^{n} \theta_j d(\log p_j) + \sum_{j=1}^{n} \omega_{ij} d(\log p_j).$$

Note that the seasonality terms, errors, and t subscripts are ignored for convenience. Also note that $\Theta = \gamma\psi/(\gamma - \psi)$. Using equation (4), we derive the unconditional import demand elasticities. Solving equation (4) for $d(\log q_i)/d(\log p^*)$, we get the output-price elasticity, which is the percentage change in imports from the ith country with respect to a percentage change in the output price:

$$(5) \quad \eta_{p^*} = \frac{d(\log q_i)}{d(\log p^*)} = \frac{\theta_i \Theta}{f_i}.$$

Similarly, we can derive the unconditional own- and cross-price elasticity, which is the percentage change in imports from the ith country with respect to a percentage change in price in country j:

$$(6) \quad \eta_{ij} = \frac{d(\log q_i)}{d(\log p_j)} = \frac{-\Theta\theta_i\theta_j}{f_i} + \frac{\omega_{ij}}{f_i}.$$

The first term in equation (6) ($-\Theta\theta_i\theta_j/f_i$) is the indirect effect of a price change and accounts for the effect of import prices on total expenditures. Note that the second term (ω_{ij}/f_i) is the conditional price elasticity, which measures the effect of changes in relative import prices. These two effects are analogous to the income and substitution effects in consumer theory.

Data and Estimation

We obtained Chinese import data (quantity and value) from the World Trade Atlas® database, Global Trade Information Services, Inc., which are reported by China Customs. Imports are defined according to the Harmonized Commodity Description and Coding System (HS) classification 5201: *cotton, not carded or combed*. Quantities are measured in kilograms and values are in U.S. dollars and include product cost, insurance, and freight (CIF). The data are monthly and span the period January 2005−December 2010. We considered this period because the expiration of the Multi-Fiber Arrangement in January 2005 marked a new era in Chinese cotton demand. For instance, MacDonald (2006) notes that China's cotton trouser exports to the United States increased over 1,000% in 2005. Such a major change in policy undoubtedly changed China's cotton market structurally.[5] To account for the competition across exporting sources, we disaggregated China's imports by country of origin: United States, India, Uzbekistan, C-4, and *the rest of the world* (ROW). C-4 is an aggregation of Benin, Burkina Faso, Chad, and Mali, and ROW is an aggregation of all countries not specified.[6]

We used unit values (value ÷ quantity) as proxies for import prices, which is a common practice because actual prices are often difficult to obtain. When trade is dominated by nonprice competition, unit values may not be valid proxies for prices, thereby limiting their usefulness in estimating import demand (Gehlhar and Pick, 2002). When nonprice competition is based on quality, Angus (1987) notes that unit values will typically respond less than one for one to prices when buyers respond by changing quality as well as quantity. If within-source quality differences are substantial, then unit values may not fully reflect changes in cotton prices for a particular source, but across-source quality differences should not be problematic because the demand equations are source-specific. Although the criticism of unit values is valid, the empirical evidence is mixed. For instance, Shiells (1991) examined the effects of using unit values instead of prices when estimating import demand elasticities. His results for 12 commodity groups at the three- and four-digit SITC level failed to reveal any significant differences between the estimated elasticities of the two measures.

Although it would be optimal to use a representative domestic price as the output price, data on China's domestic market are not easy to obtain and are considered unreliable (MacDonald and Whitley, 2009). However, because exports are important to the Chinese textile industry, changes in the export market also affect China's demand for cotton. Thus, we used China's cotton fabric export price as a proxy for the output price, which is defined according to the HS classification 5208: *woven fabrics of cotton, containing* 85% *or more cotton by weight, weighing not more than* 200 *G/M*^{2}. Similar to domestic fabric prices, an increase in the export price would encourage more fabric production resulting in increased demand for imported cotton.[7] Summary statistics for model variables are reported in Table 2.

In estimating the model, continuous log differences are replaced with finite one-period log differences (Theil, 1980). Thus, the quantity and price terms are approximated as $d(\log q_t) \approx \log q_t - \log q_{t-1}$ and $d(\log p_t) \approx \log p_t - \log p_{t-1}$. f_{it} is replaced with $\bar{f}_{it} = 0.5(f_{it} + f_{it-1})$, which is the conditional import share averaged over the periods t and $t-1$. The Divisia volume index $d(\log Q_t)$ is replaced with a discrete measure DQ_t where $d(\log Q_t) \approx DQ_t = \sum_{i=1}^{n} \bar{f}_{it}(\log q_{it} - \log q_{it-1})$, and the Frisch

[5] Before 2003, China's cotton imports were a fraction of imports today. Although imports in 2003 and 2004 are comparable to 2005, these years were not considered as a result of excessive zeros for a number of countries, which is particularly problematic when estimating a model in log differences.

[6] Initially, Australia and Brazil were also considered as exporting sources. However, China's imports from Brazil were relatively small throughout the data period and were at times zero. We found that the demand estimates were sensitive to how these zeros were treated and thought it better to add Brazil to ROW. Although imports from Australia are comparable to the C-4, as a result of econometric problems, we added Australia to ROW as well.

[7] Export prices are reported by China Customs, measured in U.S. dollars per square meter, and based on free-on-board (FOB) export values.

Table 2. Summary Statistic for Model Variables

	Mean	Standard Deviation	Minimum	Maximum
Country	Quantity (million kg)			
United States	95.57	53.87	20.37	271.72
India	44.41	49.70	0.07	237.35
Uzbekistan	21.62	14.03	0.15	68.34
Africa (C-4)	16.46	11.55	0.09	48.24
ROW	36.16	22.80	6.32	122.57
	Price ($/kg)			
United States	1.52	0.28	1.13	2.40
India	1.49	0.31	1.13	2.74
Uzbekistan	1.49	0.31	1.13	3.07
Africa (C-4)	1.45	0.23	1.10	2.02
ROW	1.55	0.27	1.16	2.54
Export price ($/meter)	1.05	0.12	0.86	1.51
	Value (million $)			
United States	142.65	76.84	27.57	371.27
India	70.48	97.05	0.15	650.97
Uzbekistan	32.84	24.89	0.20	130.14
Africa (C-4)	23.09	15.10	0.18	61.49
ROW	55.78	35.01	9.13	161.25
	Market share (%)			
United States	45.82	15.46	14.57	78.28
India	17.99	16.70	0.09	61.93
Uzbekistan	10.43	7.07	0.13	33.30
Africa (C-4)	7.43	4.70	0.03	22.21
ROW	18.33	9.28	2.71	45.05

Source: Authors' calculations using data from the World Trade Atlas® database.
ROW, rest of the world.

import price index is also replaced with a discrete measure DP'_t where $d(\log P'_t) \approx DP'_t = \sum_{i=1}^{n} \theta_i(\log p_{it} - \log p_{it-1})$.

The demand system represented by equations (1) and (2) is estimated using the LSQ procedures in TSP (version 5.0), which uses the generalized Gauss-Newton method to estimate the parameters in the system. Theil (1980) shows that if the parameters in equations (1) and (2) are assumed constant and the errors normally distributed, then $\text{cov}(\varepsilon_{it}, \mu_t) = 0$. This indicates that the total expenditure equation and import allocation system do not have to be estimated jointly. As a result of the adding-up property, the allocation system is singular and requires that we delete an equation for estimation. As noted by Barten (1969), estimates are invariant to the chosen deleted equation.

Preliminary diagnostic tests indicated that the errors in equations (1) and (2) were well behaved, i.e., serially uncorrelated, homoskedastic, and normally distributed. However, we did find evidence of import price endogeneity for India and the C-4. To mitigate this problem, we lagged their prices one period. Likelihood ratio tests were used to test the homogeneity and symmetry constraints. Both properties failed to be rejected at the 0.01 significance level. All reported estimates in the following section are homogeneity and symmetry constrained.

Empirical Results

The demand estimates for imported cotton in China are reported in Table 3. The marginal share estimates are all positive and significant

Table 3. Conditional Demand Estimates for China's Cotton Imports by Source

		Conditional Price Effects (ω)					Seasonality	
Country	Marginal Share (θ)	United States	India	Uzbekistan	Africa (C-4)	ROW	α_1(cos)	α_2(sin)
United States	0.318[a]	–0.630[a]	0.065	0.019[a]	0.140	0.406[a]	–0.068[a]	0.067[a]
	(0.032)	(0.221)	(0.175)	(0.007)	(0.115)	(0.133)	(0.020)	(0.020)
India	0.385[a]		–0.118	0.022[a]	0.023	0.008	0.080[a]	–0.056[a]
	(0.033)		(0.212)	(0.007)	(0.095)	(0.101)	(0.020)	(0.020)
Uzbekistan	0.151[a]			–0.064[a]	0.009[a]	0.014[a]	0.044[b]	0.000
	(0.035)			(0.007)	(0.003)	(0.003)	(0.022)	(0.022)
Africa (C-4)	0.046[a]				–0.140	–0.032	–0.024[a]	0.008
	(0.013)				(0.127)	(0.104)	(0.008)	(0.008)
ROW	0.100[a]					–0.395[a]	–0.033[a]	–0.019[b]
	(0.015)					(0.152)	(0.009)	(0.010)

[a] Significance level = 0.01.
[b] Significance level = 0.05.
Notes: Homogeneity and symmetry are imposed. Asymptotic standard errors are in parentheses. The R^2 for each equation in order listed in the table is 0.687, 0.730, 0.711, 0.261, and 0.456. ROW, rest of the world.

at the 0.01 significance level. These estimates measure how a unit increase in total import expenditures is allocated across the exporting sources. Cotton imports from the United States and India are the most responsive to an increase in expenditures (0.318 and 0.385, respectively). They are followed by Uzbekistan (0.151) and ROW (0.100). The C-4 countries are the least responsive where an increase in total expenditures results in exports to China increasing by 0.046, less than 5 cents for every dollar. Being handpicked, C-4 cotton is supposed to have a comparative advantage; however, misgivings about contamination from foreign matter cause C-4 cotton to be traded at a discount relative to machine-picked alternatives (Estur, 2008). Thus, the low responsiveness to total expenditures may be the result of perceptions about contamination and quality.

The conditional own-price estimates are presented along the diagonal in Table 3. The estimates are negative, which is consistent with theory and ensure that the matrix of price effects ($\boldsymbol{\Omega}$) is negative semidefinite. Of the countries considered, three own-price estimates are significant (United States, Uzbekistan, and ROW). The own-price estimate for the United States, Uzbekistan, and ROW are –0.630, –0.064, and –0.395, respectively. We discuss these estimates in more detail when they are converted to elasticities.

The cross-price estimates indicate that cotton imports by country are for the most part substitutes in the Chinese market. The most significant competition is between the United States and ROW (0.406). Note that ROW is mostly comprised of imports from Australia and to a lesser degree Brazil, Mexico, Egypt, and African countries other than the C-4.[8] The substitute relationship between the United States and ROW could be the result of U.S. and Australian cotton being highly regarded in world markets. Both are used to produce high-quality textiles and have very low rates of contamination (Ruh, 2005). What is particularly interesting is that cotton from Uzbekistan is price-competitive (conditionally) with all exporting countries. However, when considering the total effect of prices (expenditure and relative price effect), the only significant substitute relationship is between the United States and ROW (see the unconditional elasticities in Table 4).

The conditional and unconditional demand elasticities are reported in Table 4. The conditional expenditure elasticity, which measures the percentage responsiveness of an import to

[8] Australia accounts for approximately 35% of ROW and Brazil approximately 10%.

Table 4. Conditional and Unconditional Import Demand Elasticities

	Conditional Elasticities			Unconditional Price Elasticities					
					Cross-price				
Country	Expend.	Own-price	Export Price	Own-price	United States	India	Uzbekistan	Africa (C-4)	ROW
United States	0.712[a]	–1.408[a]	0.446[a]	–1.550[a]		–0.026	–0.025	0.293	0.862[a]
	(0.072)	(0.493)	(0.122)	(0.500)		(0.394)	(0.027)	(0.257)	(0.299)
India	2.115[a]	–0.645	1.325[a]	–1.156	–0.065		–0.081	0.065	–0.088
	(0.179)	(1.164)	(0.355)	(1.159)	(0.968)		(0.077)	(0.517)	(0.553)
Uzbekistan	1.460[a]	–0.614[a]	0.915[a]	–0.752[a]	–0.110	–0.143		0.047	0.043
	(0.338)	(0.071)	(0.315)	(0.081)	(0.116)	(0.135)		(0.029)	(0.042)
Africa (C-4)	0.565[a]	–1.733	0.354[a]	–1.749	1.621	0.145	0.060		–0.431
	(0.166)	(1.564)	(0.137)	(1.563)	(1.420)	(1.163)	(0.037)		(1.284)
ROW	0.535[a]	–2.125[a]	0.335[a]	–2.158[a]	2.074[a]	–0.086	0.024	–0.188	
	(0.083)	(0.817)	(0.100)	(0.818)	(0.720)	(0.541)	(0.024)	(0.559)	

[a] Significance level = 0.01.
Notes: Asymptotic standard errors are in parentheses. ROW, rest of the world.

a percentage change in total import expenditures, is significant for all countries. The expenditure elasticity is largest for cotton from India (2.115) and Uzbekistan (1.460). The estimates for the United States (0.712), C-4 (0.565), and ROW (0.535) are significantly smaller. Recall from Table 1 that India is the only country to experience consistent market share growth during the data period, increasing from 4.7% in 2005 to 30.7% by 2010. The large expenditure elasticity reflects the fact that much of the growth in China's cotton imports is the result of increased imports from India.

An estimate of the deflated output-price effect $\Theta = \gamma\psi/(\gamma - \psi)$ is needed to derive the unconditional elasticities. First, the marginal share estimates reported in Table 3 are used to derive the Frisch import price index. Second, the fabric export price (in log differences) and the Frisch import price index are then used in estimating equation (2). The results indicate that the output price effect (Θ) is 0.626 (0.159), which is significant at the 0.01 level and indicates that a percentage increase in the deflated output price results in total import expenditures increasing by 0.626%.[9]

The unconditional own- and cross-price elasticities are also reported in Table 4. As expected, import demand becomes more elastic when the expenditure effect of a price change is accounted for. However, the unconditional own-price elasticities for the United States (–1.550), Uzbekistan (−0.752), and ROW (–2.158) are not significantly different from their corresponding conditional elasticities which indicates that the expenditure effect is relatively small when compared with the relative price effect. Although the own-price estimates suggest that Chinese demand for U.S. and ROW cotton is elastic, given the standard errors, there is no significant difference between the own-price elasticities for the three sources.

Although imports by country are for the most part unrelated when the relative price and expenditure effects are accounted for, there is still a significant substitute relationship between the United States and ROW. Note that given a percentage increase in U.S. prices, imports from the ROW increase by 2.07%, and given a percentage increase in ROW prices, imports from the U.S. increase by 0.862%. The larger responsiveness of ROW to U.S. prices is likely the result of the volume of imports from the United States being at least two times greater than imports from ROW. The insignificant relationship between the United States and sources other than ROW suggests that these countries would not benefit from an increase in U.S. prices.

[9] The standard error is in parentheses.

Forecasting Procedure and Import Demand Simulation

One of our objectives is to simulate the impact of a U.S. price shock on China's demand for imported cotton. It has been argued that domestic and export subsidies encourage excess production and exports and hence depress global cotton prices. If so, a positive price shock could be viewed as a consequence of U.S. subsidy reductions. For instance, Pan, Hudson, and Ethridge (2010) find that the elimination of U.S. cotton programs (direct payments, target price, and loan rate) would raise the world price index for cotton by slightly less than 5% per year over a 5-year period.

Following Kastens and Brester (1996), import demand projections are derived using an elasticity-based forecasting equation. The unconditional elasticities are used because they encompass the complete effect of a price change making them more suitable for policy projections. Based on equation (4), the elasticity forecasting equation is as follows:

$$(7)\quad q_{i1} = \left(\eta_{p*}\left[\frac{p_1^* - p_0^*}{p_0^*}\right] + \sum_{j=1}^{n}\eta_{ij}\left[\frac{p_{j1} - p_{j0}}{p_{j0}}\right]\right)q_{i0} + q_{i0}.$$

Note that η_{p*} and η_{ij} are the unconditional import demand elasticities derived using equations (5) and (6).

Equation (7) states that the quantity imported from country i in the projection period (1) is a function of the quantity imported during the base period (0) and the percentage changes in the export price and source-specific import prices from the base period to the projection period. A number of studies have compared model and elasticity-based forecasts using demand systems. These include Gustavsen and Rickertsen (2003), Kastens and Brester (1996), and Muhammad (2007). These studies concluded that demand forecasts derived from elasticities are superior to model-based forecasts.

The impact of a \$0.20/kg U.S. price shock on China's import demand is considered for the import demand simulations, which is a 10% increase when compared with 2010 prices and is consistent with the subsidy elimination response identified in the literature. For instance, Rivoli (2005) indicates that the removal of U.S. subsidies would increase the market price of cotton by anywhere from 3% to 15%. Pan, Hudson, and Ethridge (2010) indicate that world prices would increase by slightly less than 5% per year, Pan et al. (2006) suggest an even smaller increase of 2%, and Schmitz, Rossi, and Schmitz (2007) indicate that world cotton prices have been depressed by approximately 21% per year as a result of U.S. subsidies from 1999–2004.

Impulse response functions are used to assess the impact of U.S. cotton prices on prices in India, Uzbekistan, C-4, and ROW and are derived by a VAR procedure. The VAR representation is as follows:

$$(8)\quad \mathrm{p}_t = \alpha + \mathrm{A}_1\mathrm{p}_{t-1} + \mathrm{A}_2\mathrm{p}_{t-2} + \cdots + \mathrm{A}_k\mathrm{p}_{t-k} + \boldsymbol{\varepsilon}_t.$$

p is the vector of import prices (in levels) for the United States, India, Uzbekistan, C-4, and ROW. k is the lag order, α is a vector of constants, A_i ($n \times n$) is a coefficient matrix, and $\boldsymbol{\varepsilon}$ is a vector of random disturbances. The advantage of using levels is that the estimates

Table 5. Chi-square Statistics for Granger Causality Test

Price of Cotton From	Dependent Variable: United States	Uzbekistan	India	Africa (C-4)	ROW
United States		0.002 [0.968]	0.250 [0.617]	3.465 [0.063]	2.586 [0.108]
Uzbekistan	0.027 [0.869]		8.002 [0.005]	0.693 [0.405]	2.262 [0.133]
India	1.485 [0.223]	3.606 [0.058]		0.001 [0.982]	1.828 [0.176]
Africa (C-4)	1.125 [0.289]	0.032 [0.858]	0.027 [0.869]		2.872 [0.090]
ROW	1.175 [0.278]	0.086 [0.770]	2.970 [0.085]	5.938 [0.015]	

Notes: Probability values are in brackets. ROW, rest of the world.

remain consistent regardless of prices being integrated or not. Furthermore, standard inference on impulse responses in levels will remain asymptotically valid, and the inference is asymptotically the same even in the presence of cointegrated prices (Lütkepohl and Reimers, 1992; Sims, Stock, and Watson, 1990).

We use the Schwartz Bayesian Criterion (SBC) to choose the lag order (*k*). A 1-month lag specification was found to be optimal. We also perform Granger causality tests to determine the relationship among import prices. Our results are reported in Table 5 and indicate that India, Uzbekistan, C-4, and ROW cotton prices do not Granger cause U.S. cotton prices; Indian cotton prices Granger cause Uzbekistan cotton prices; Uzbekistan and ROW cotton prices Granger cause India cotton prices; U.S. and ROW cotton prices Granger cause C-4 cotton prices; and C-4 cotton prices Granger cause ROW cotton prices.

The impulse response results are shown in Figure 1. The solid line shows the mean price response and the dotted lines are the responses

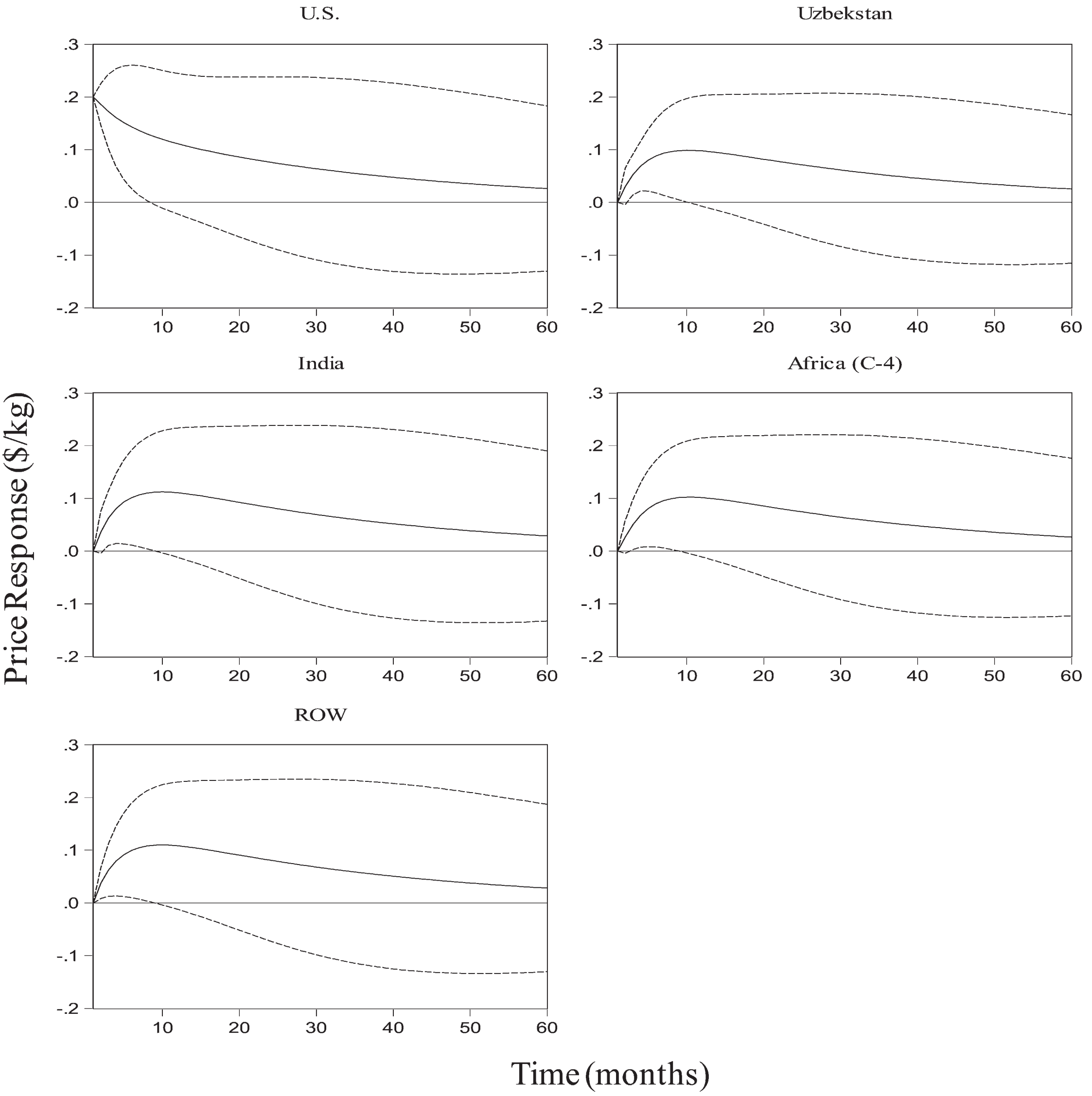

Figure 1. Impulse Response Results Given a $0.20/kg U.S. Price Shock

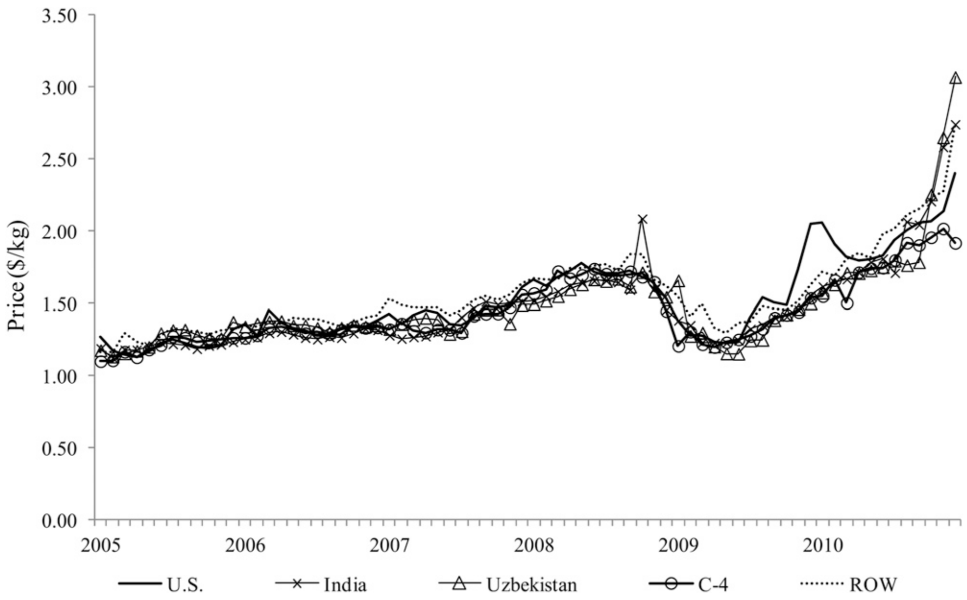

Figure 2. Cotton Import Prices in China by Exporting Country: January 2005–December 2010

two standard deviations from the mean. Immediately after the $0.20 price shock, U.S. prices decline and the effect on Uzbekistan, India, C-4, and ROW is fully realized within 1 year (at 10 months). At 10 months, the increase in U.S. price is $0.12, down 8 cents, whereas the price increase for Uzbekistan, India, C-4, and ROW is $0.10, $0.11, $0.10, and $0.11, respectively. Because import prices in China are highly correlated across exporting countries, the similarity in price responsiveness should not be surprising. In fact, the correlation between prices ranges from as high as 0.95 for India and Uzbekistan to 0.85 for the United States and Uzbekistan (see Figure 2).[10] After 10 months, all prices start to decline and approach their initial values around 60 or more months. However, note that the confidence bands for each time path include the zero axis before the end of the first year, which is an indication that a U.S. price shock may not be long-lasting. These results are similar to findings in Pan et al. (2006). They indicate that the increase in world prices resulting from U.S. subsidy elimination would be mitigated within a short time period as a result of expanded production in competing countries.

Using equation (7) and the impulse response relationships, we make import demand projections given a $0.20 shock in U.S. cotton prices. The average price, total quantity and value, and market share in 2010 are used as the baseline or reference values. We highlight three distinct periods on the impulse response time path. First, we consider the initial price shock in which U.S. prices increase but prices in India, Uzbekistan, C-4, and ROW have yet to respond (short-run). Second, we highlight the time period when prices peak (10 months after the initial shock). Third, because the results indicate that a U.S. price shock will not be long-lasting, we highlight the final period when prices return to their initial levels (long-run). Results are reported in Table 6.

The short-run results show that a $0.20 U.S. price shock will have a relatively large effect on Chinese cotton imports from the United States, C-4, and ROW. U.S. exports decrease by 16% and market share falls by 3%. The quantity and value of C-4 cotton will both increase by 16.9%

[10] The correlation in prices is not an issue when using the Rotterdam model because all variables are in log-differential form. Although prices are highly correlated in levels, the correlation in log differences is not as strong.

Table 6. Import Projections Given a $0.20/kg U.S. Price Shock

Exporting Country	Baseline Price ($/kg)	Baseline Quantity (mil.kg)	Baseline Value ($ mil.)	Baseline Share (%)	Short-Run Price ($/kg)	Short-Run Quantity (mil.kg)	Short-Run Value ($ mil.)	Short-Run Share (%)	Difference Price ($/kg)	Difference Quantity (%)	Difference Value (%.)	Difference Share (%)
United States	1.98	1,008.61	1,998.13	35.31	2.18	849.45	1,855.37	32.32	0.20	−15.78	−7.14	−3.00
India	2.00	868.02	1,737.12	30.70	2.00	862.48	1,726.29	30.07	0.00	−0.64	−0.62	−0.63
Uzbekistan	2.01	344.83	692.56	12.24	2.01	340.96	684.95	11.93	0.00	−1.12	−1.10	−0.31
Africa (C-4)	1.78	122.02	217.47	3.84	1.78	142.67	254.21	4.43	0.00	16.93	16.90	0.58
ROW	2.05	495.14	1,012.89	17.90	2.04	597.25	1,220.25	21.25	0.00	20.62	20.47	3.35
Total		2,838.61	5,658.16	100.00		2,792.81	5,741.08	100.00		−1.61	1.47	
	Baseline Price ($/kg)	Baseline Quantity (mil.kg)	Baseline Value ($ mil.)	Baseline Share (%)	Peak Prices Price ($/kg)	Peak Prices Quantity (mil.kg)	Peak Prices Value ($ mil.)	Peak Prices Share (%)	Difference Price ($/kg)	Difference Quantity (%)	Difference Value (%.)	Difference Share (%)
United States	1.98	1,008.61	1,998.13	35.31	2.10	950.35	1,998.16	35.43	0.12	−5.78	0.00	0.12
India	2.00	868.02	1,737.12	30.70	2.11	807.50	1,702.56	30.19	0.11	−6.97	−1.99	−0.51
Uzbekistan	2.01	344.83	692.56	12.24	2.11	328.11	693.39	12.30	0.10	−4.85	0.12	0.06
Africa (C-4)	1.78	122.02	217.47	3.84	1.88	118.00	222.20	3.94	0.10	−3.29	2.18	0.10
ROW	2.05	495.14	1,012.89	17.90	2.16	474.00	1,023.18	18.14	0.11	−4.27	1.02	0.24
Total		2,838.61	5,658.16	100.00		2,677.96	5,639.49	100.00		−5.66	−0.33	
	Baseline Price ($/kg)	Baseline Quantity (mil.kg)	Baseline Value ($ mil.)	Baseline Share (%)	Long-Run Price ($/kg)	Long-Run Quantity (mil.kg)	Long-Run Value ($ mil.)	Long-Run Share (%)	Difference Price ($/kg)	Difference Quantity (%)	Difference Value (%.)	Difference Share (%)
United States	1.98	1,008.61	1,998.13	35.31	1.98	979.58	1,941.54	35.01	0.00	−2.88	−2.83	−0.30
India	2.00	868.02	1,737.12	30.70	2.00	860.86	1,723.98	31.09	0.00	−0.83	−0.76	0.39
Uzbekistan	2.01	344.83	692.56	12.24	2.01	343.16	689.48	12.43	0.00	−0.48	−0.44	0.19
Africa (C-4)	1.78	122.02	217.47	3.84	1.78	119.18	212.45	3.83	0.00	−2.33	−2.31	−0.01
ROW	2.05	495.14	1,012.89	17.90	2.05	477.54	977.64	17.63	0.00	−3.55	−3.48	−0.27
Total		2,838.61	5,658.16	100.00		2,780.32	5,545.08	100.00		−2.05	−2.00	0.00

ROW, rest of the world.

and market share by 0.58%. These results are based on the relatively large elasticity for C-4 cotton and U.S. prices (1.621). Although large, this elasticity is not significant indicating that the projected changes in the quantity, value, and market share for the C-4 are not statistically different from zero. ROW imports are projected to increase by approximately 21% and the market share by 3.4%, and unlike the C-4, the elasticity for ROW cotton and U.S. prices (2.074) is significant. If U.S. cotton subsidies depress U.S. prices, the initial effect of subsidy elimination would make the ROW countries better off, but the impact on the remaining countries is negligible.

The U.S. price shock will cause prices in competing countries to also increase. As a result, China will decrease its cotton imports from all sources. At peak prices (10 months after the U.S. price shock), the United States, India, and Uzbekistan experience the largest quantity decrease at 5.8%, 7.0%, and 4.9%, respectively. Overall, total imports fall by 5.7%. Although quantities are projected to fall, export earnings increase for all countries except India. However, there is very little change in market share. The C-4 experiences the largest increase in export earnings at 2.2%. In comparing the short-run and peak price projections, it is clear that the relationship between the United States and the C-4 has more to do with how U.S. prices impact global prices rather than any substitute relationship. Results suggest that U.S. subsidies affect C-4 countries only to the degree that these subsidies depress global prices. However, even the peak-price result for the C-4 should be taken with caution because neither the own- nor cross-price elasticities are significant suggesting that this change could also be negligible.

In the long run, all prices return to their initial level. Projections show that the Chinese market does not fully recover from the period of higher prices. Note that total cotton imports are down by 2% when compared with the baseline period, and ROW exports are down by 3.6%, U.S. exports by 2.9%, and C-4 exports by 2.3%. It could be that these changes are not statistically significant, which is an indication that the Chinese market returns to the baseline in the long run. Alternatively, it could also be that the period of higher prices results in an increase in demand for competing products such as synthetic fabrics and domestic cotton. Thus, when prices return to their baseline levels, cotton imports may not fully recover.

Summary and Conclusion

In this study, we examined the factors that determine the demand for imported cotton in China. Given the claim that exporting countries are negatively affected by U.S. cotton subsidies, we focused on the price competition between the United States and competing exporting countries in the Chinese cotton market. Because cotton is an intermediate good, import demand was modeled as input demand and the differential approach to the theory of the firm was used for the analysis. The import demand estimates were used to derive unconditional demand elasticities that were used in simulating the effects of a U.S. price shock on China's import demand by exporting country.

Overall, results show a particularly strong competitive relationship between U.S. and ROW cotton in the Chinese market. However, the relationship between the United States and the C-4 was insignificant. In comparing the import demand projections, results showed that the relationship between the United States and the C-4 has more to do with how U.S. prices impact global prices rather than any substitute or competitive relationship. This suggests that U.S. subsidies affect C-4 countries if subsidies depress global prices, but even this may not be the case because the C-4's own-price effect was insignificant. However, in the case of the ROW, which includes countries like Australia and Brazil, there is both a competitive relationship as well as a global price effect. However, it appears that the global price effect works against the substitute relationship. Thus, if U.S. subsidies are making ROW countries worse off, this negative effect is lessened when global prices respond accordingly. Lastly, we found that the spike in global prices in response to a U.S. price shock would not be permanent, and when prices return to their initial levels, Chinese cotton imports would not fully recover from the period of high prices. Our findings are based on analysis of China, the largest global cotton importer. Further analysis would be useful to determine if our findings hold with a more comprehensive list of cotton producers and importers.

References

Alston, J.M., and H. Brunke. "Impacts of Reductions in U.S. Cotton Subsidies on World Price of Cotton and Implications for West African Cotton Producers." Oxfam America Research Report, November 2006.

Alston, J.M., C.A. Carter, R. Green, and D.H. Pick. "Whither Armington Trade Models?" *American Journal of Agricultural Economics* 72(1990):455–67.

Alston, J.M., D.A. Sumner, and H. Brunke. "Impacts of Reductions in U.S. Cotton Subsidies on West African Cotton Producers." Oxfam America Research Report, June 2007.

Anderson, K., E. Valenzuela, and L.A. Jackson. "Recent and Prospective Adoption of Genetically Modified Cotton: A Global Computable General Equilibrium Analysis of Economic Impacts." *Economic Development and Cultural Change* 56(2008):265–96.

Angus, D. "Estimation of Own- and Cross-Price Elasticities from Household Survey Data." *Journal of Econometrics* 36(1987):7–30.

Armington, P.S. "A Theory of Demand for Products Distinguished by Place of Production." *International Monetary Fund Staff Papers* 16(1969):159–76.

Arnade, C., D. Pick, and M. Gehlhar. "Testing and Incorporating Seasonal Structures Into Demand Models for Fruit." *Agricultural Economics* 33(2005):527–32.

Arnade, C., D.H. Pick, and U. Vasavada. "Testing Dynamic Specification for Import Demand Models: The Case of Cotton." *Applied Economics* 26(1994):375–80.

Audet, D. "Smooth as Silk? A First Look at the Post MFA Textiles and Clothing Landscape." *Journal of International Economic Law* 10(2007):267–84.

Barten, A. "Maximum Likelihood Estimation of a Complete System of Demand Equations." *European Economic Review* 1(1969):7–73.

Chang, H.-S., and C. Nguyen. "Elasticity of Demand for Australian Cotton in Japan." *The Australian Journal of Agricultural and Resource Economics* 46(2002):99–113.

Clements, K.W., and H. Theil. "A Simple Method of Estimating Price Elasticities in International Trade." *Economics Letters* 1,2(1978):133–37.

Davis, G.C. "Product Aggregation Bias as a Specification Error in Demand Systems." *American Journal of Agricultural Economics* 79(1997): 100–109.

Deaton, A., and J. Muellbauer. "An Almost Ideal Demand System." *The American Economic Review* 70(1980):312–26.

Estur, G. "Quality and Marketing of Cotton Lint in Africa." Washington, D.C.: World Bank, African Region Working Paper 121, October 2008.

Fang, C., and B.A. Babcock. "China's Cotton Policy and the Impact of China's WTO Accession and Bt Cotton Adoption on the Chinese and U.S. Cotton Sectors." Working Paper 03-WP-322, Center of Agriculture and Rural Development, Iowa State University, 2003.

Frisvold, G.B., J.M. Reeves, and R. Tronstad. "Bt Cotton Adoption in the United States and China: International Trade and Welfare Effects." *AgBioForum* 9,2(2006):69–78.

Fuller, F., J. Beghin, S. De Cara, J. Fabiosa, C. Fang, and H. Matthey. "China's Accession to the World Trade Organization: What Is at Stake for Agricultural Markets?" *Review of Agricultural Economics* 25(2003):399–414.

Ge, Y., H.H. Wang, and S.K. Ahn. "Cotton Market Integration and the Impact of China's New Exchange Rate Regime." *Agricultural Economics* 41(2010):443–51.

Gehlhar, M.J., and D.H. Pick. "Food Trade Balances and Unit Values: What Can They Reveal About Price Competition?" *Agribusiness* 18(2002):61–79.

Gustavsen, G.W., and K. Rickertsen. "Forecasting Ability of Theory-constrained Two-stage Demand Systems." *European Review of Agriculture Economics* 30(2003):539–58.

Hanson, R. "Senegal Cotton and Products West Africa Cotton Annual 2007." Washington, D.C.: Foreign Agricultural Service, U.S. Department of Agriculture Service, GAIN Report SG7011, May 2007.

Huang, J., R. Hu, H. van Meijl, and F. van Tongeren. "Biotechnology Boosts to Crop Productivity in China: Trade and Welfare Implications." *Journal of Development Economics* 75(2004): 27–54.

Jales, M. "How Would a Trade Deal on Cotton Affect Exporting and Importing Countries?" Geneva, Switzerland: International Centre for

Trade and Sustainable Development, Issue Paper No. 26, May 2010.

Kastens, T.L., and G.W. Brester. "Model Selection and Forecasting Ability of Theory-constrained Food Demand Systems." *American Journal of Agricultural Economics* 78(1996):301–12.

Laitinen, K. *A Theory of the Multiproduct Firm*. Amsterdam: North-Holland Publishing Co., 1980.

Li, H., S. Mohanty, and S. Pan. "The Impacts of MFA Elimination on Chinese Fiber Markets." *Journal of International Agricultural Trade and Development* 1(2005):71–91.

Lütkepohl, H., and H.E. Reimers. "Impulse Response Analysis of Cointegrated Systems." *Journal of Economic Dynamics & Control* 16(1992): 53–78.

MacDonald, S. "The World Bids Farewell to the Multifiber Arrangement." Amber Waves 4,1(2006):20–5.

MacDonald, S., S. Pan, A. Somwaru, and F. Tuan. "China's Role in World Cotton and Textile Markets: A Joint Computable General Equilibrium/Partial Equilibrium Approach." *Applied Economics* 42(2008):875−85.

MacDonald, S., and S. Whitley. "Fiber Use for Textiles and China's Cotton Textile Exports." Washington, D.C.: Economic Research Service, U.S. Department of Agriculture, Outlook Report CWS-08I-01, March 2009.

Muhammad, A. "Would African Countries Benefit From the Termination of Kenya's Economic Partnership Agreement (EPA) with the EU? An Analysis of EU Demand for Imported Roses." *Journal of Agricultural Economics* 60(2009):220–38.

———. "The Impact of Increasing Non-agricultural Market Access on EU Demand for Imported Fish: Implications for Lake Victoria Chilled Fillet Exports." *European Review of Agriculture Economics* 34(2007):461–77.

Mutuc, M.E., S. Mohanty, D. Ethridge, and D. Hudson. "The Effects of the Removal of U.S. Safeguards on Imports from China." *Applied Economics Letters* 18(2011):901–13.

Pan, S., D. Hudson, and D.E. Ethridge. "Market Structure Impacts on Market Distortions from Domestic Subsidies: The U.S. Cotton Case." *Estey Centre Journal of International Law and Trade Policy* 11(2010):417–35.

Pan, S., S. Mohanty, M. Welch, D. Ethridge, and M. Fadiga. "Effects of Chinese Currency Revaluation on World Fiber Markets." *Contemporary Economic Policy* 25(2007):185–205.

———. "The Impacts of U.S. Cotton Programs on the World Market: An Analysis of Brazilian WTO Petition." *Journal of Cotton Science* 10(2006):180–92.

Quirke, D. *Trade Distortions and Cotton Markets: Implications for Global Cotton Producers*. Canberra, Australia: Cotton Research and Development Corporation, Centre for International Economics, 2002.

Rivoli, P. *The Travels of a T-Shirt in the Global Economy*. New Jersey: John Wiley and Sons, Inc., 2005.

Ruh, P.S. *The Cotton Trade Today. Cotton Trade Manual*. Secretariat of the International Cotton Advisory Council, eds. Cambridge, U.K.: Woodhead Publishing, 2005.

Schmitz, A., F. Rossi, and T. Schmitz. "U.S. Cotton Subsidies: Drawing a Fine Line on the Degree of Decoupling." *Journal of Agricultural and Applied Economics* 39(2007):135–49.

Schnepf, R. "Brazil's WTO Case Against the U.S. Cotton Program." Washington, D.C.: Congressional Research Service, CRS Report RL32571, June 2010.

Shiells, C.R. "Errors in Import-demand Estimates Based Upon Unit-value Indexes." *The Review of Economics and Statistics* 73(1991):378–82.

Sims, C.A., J.H. Stock, and M.W. Watson. "Inference in Linear Time Series with Some Unit Roots." *Econometrica* 58(1990):113–44.

Theil, H. "The Independent Inputs of Production." *Econometrica* 45(1977):1303–27.

———. *The System-wide Approach to Microeconomics*. Chicago, IL: University of Chicago Press, 1980.

United Nations Commodity Trade Statistics (UN Comtrade) Database. (2011). Internet site: http://comtrade.un.org/db/ (Accessed March 2011).

Washington, A.A., and R.L. Kilmer. "The Production Theory Approach to Import Demand Analysis: A Comparison of the Rotterdam Model and the Differential Production Approach." *Journal of Agricultural and Applied Economics* 34(2002):431–43.

Xiao, S. "Welfare Change of China's Cotton Supply Chain Under the Shock of Financial Crisis." *China Agricultural Economic Review* 2(2010):94–106.