Dynamic Economic Relationships Among China's Market for Raw U.S. Cotton and U.S.–Bound Exports of Chinese and Non-Chinese Apparel: Preliminary Empirical Findings

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In an increasingly globalized trading arena, import and export flows are often directly related. For example, U.S. cotton exports to China theoretically can be tied as inputs to Chinese exports of U.S–bound apparel. Intuitively, increases in U.S. purchases of Chinese exports may lead to increased Chinese input demands for U.S. raw cotton. Increases in non-Chinese apparel exports to the U.S. market also could influence such U.S–bound Chinese exports, and in turn Chinese purchases of U.S. cotton, through indirect third-market effects. This paper empirically investigates the monthly dynamic workings and inter-relationships among the prices and quantities of Chinese exports of apparel to the U.S. market, competing non-Chinese exports of apparel to the U.S. market, and U.S. raw cotton export sales to China. This paper examines the dynamic causal relationships among prices and quantities for these three trade flows, and illuminates the dynamic monthly workings and empirically-estimated market-driving parameters for China's market for U.S.–bound apparel exports and for the U.S. apparel market for China's competitor suppliers. We also investigate China's monthly import market for U.S.-sourced raw cotton., focusing on the responsiveness of the price and volume of China-bound U.S. raw cotton exports to changes in prices and quantities of U.S–bound apparel exports.

For perhaps the first time, a vector autoregression, or VAR, model is used to model the following monthly series data from 2003–2007, all of which are taken from USITC (2008):

1. QAPCHINA: China's exports of apparel products to the United States in metric tons or MT. These are sometimes referred to as U.S. imports or purchases of Chinese apparel.
2. PAPCHINA: Prices per MT of Chinese apparel exported to the Unites States. This price is proxied by the U.S. unit value of such imports calculated from the quantity (QAPCHINA) and values.
3. QAPROW: U.S–bound apparel products from non-Chinese suppliers, in MT. These are sometimes denoted as U.S. imports or purchases of non-Chinese apparel.
4. PAPROW: Price of U.S–bound apparel products from non-Chinese suppliers, calculated from import quantity and values.
5. QUS2CH: U.S. exports of raw cotton imports to China, in MT. These are sometimes denoted as Chinese imports or purchases of U.S. raw cotton.
6. PUS2CH: Price per MT of China's imports of raw U.S. cotton calculated from the quantity variable (QUS2CHINA) and values of such imports.

We opted to use a monthly data sample covering January 2003 to December 2007. While a larger sample with pre-2003 observations would have been desirable, careful analysis suggested clear problems with statistical structural change (particularly for PUS2CHINA and QUS2CHINA) after 2002, thereby precluding use of the expanded sample without incurring serious problems with time-varying coefficients.[1] Future research should

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[1] A number of changes in the structure of the cotton trade made it difficult to compare data from before and after this point. First, despite the increase in cotton demand by China's textile industry, the Chinese government has executed a policy that does not encourage the expansion of cotton planting area. As a result, China's textile industry has relied on cotton imports to fill the gap in demand. Second, the end of the Multi-Fiber Agreement ("MFA") caused demand for Chinese textiles to

focus on larger samples as post-2002 observations increase over time.

Two sections follow. The first discusses the appropriateness of the VAR econometric procedures and the statistical adequacy of the estimated model. The second section provides an analysis of and preliminary empirical findings from the estimated model's forecast error variance (FEV) decompositions and analyses of selected endogenous shock simulations of the estimated VAR model's impulse-response function. This second section illuminates dynamic workings and the strength of dynamic causal relationships in each modeled market and across the three markets, and provides updated empirical estimates of policy-relevant market-driving elasticity parameters.

VAR Econometrics and Estimated Model Adequacy

We specified, estimated, and ultimately simulated a quarterly VAR model of the above six endogenous variables. VAR econometric procedures have been widely applied and are not recounted here. Readers interested in methodological detail are referred to seminal articles by Sims (1980) and Bessler (1984).

Considered a reduced-form framework, a VAR model is appropriately considered here because evidence suggests that the six variables are stationary in logged levels.[2] The VAR model posits each of the six variables as a function of three lags of itself and three lags of the remaining five endogenous variables.[3] We also used binary variables to account for any indirect effects on the U.S. market for apparel of the following Chinese apparel supply events: the termination of the Agreement of Textiles and Clothing in January 2005 and the June 2005 resolution between the EU and China on imposing temporary quotas on apparel imports from China.

Following the reasoning of Sims (1980) and Bessler (1984), our model was appropriately estimated with ordinary least squares. Following Andersen, Babula, Hartmann, and Rassmussen (2007) and Andersen, Hartmann, Rassmussen, and Babula (2007), the model was tested for statistical adequacy of specification with Ljung-Box portmanteau and DF unit-root tests applied to the estimated residuals. Evidence suggested that the estimated model achieved literature-established standards of adequacy.[4]

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increase. Although the MFA did not expire until January 1, 2005, the anticipation of this event likely elicited some increase in China's investment in the textile sector in the period leading up the end of the MFA. Third, the rapid growth in China's economy has caused an increased textiles demand. Fourth, China's rapid urbanization has enhanced demand for textiles. Finally, China has not enforced the tariff-rate quota that it negotiated as a part of its admittance to the WTO.

[2] See Hamilton (1994) for a discussion on the VAR model's reduced-form nature and its relationship to structural econometric models. Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests were applied to the logged levels of the six endogenous variables (see Hamilton for test procedures). The following DF or ADF $T\tau$ values were all negative and had absolute values exceeding the absolute critical values of −3.15 at the ten-percent significance level and −3.45 at the five-percent significance level: −4.9 for QAPCHINA, −6.8 for PAPCHINA, −3.9 for QAPROW, −4.7 for PAPROW, and -3.8 for QUS2CH. Following arguments in Harris (1995); Andersen, Babula, Hartmann, and Rasmussen (2007); and Andersen, Hartmann, Rasmussen, and Babula (2007), the ten-percent significance level is chosen as the primary decision rule. In that case, one rejects the null hypothesis of nonstationarity when pseudo-$T\tau$ values are negative and have absolute values that exceed those of the −3.15 critical value. The PUS2CH test value was −2.53, suggesting that evidence was marginally insufficient (and nearly sufficient) to reject the null of nonstationarity. Following arguments and recommended procedures of Kwiatowski et. al. (1994) in cases when samples are small and DF/ADF results are marginal, we further tested PUS2CH using Kwiatowski et. al.'s (1994) KPSS test as supplemental evidence in making a final decision. KPSS test evidence at the 5- and 10-percent levels was insufficient to reject the KPSS test null that PUS2CH is stationary. Given PUS2CH's very marginal DF evidence suggesting nonstationarity and the strong KPSS evidence supporting the variable's stationarity, we followed procedures recommended by Kwiatowski et. al. (1994) and Babula et. al. (2004) and concluded that PUS2CH is likely stationary.

[3] The three-order lag structure emerged from our application of Tiao and Box's (1978) lag selection procedure, the results of which are not reported here for considerations of page length.

[4] Ljung-Box portmanteau or "Q" statistics generated by the VAR model's estimated residuals were used to test the null hypothesis of model adequacy. With the VAR model's six Q-values having generated p-values above 0.05, evidence in each equation's case was insufficient to reject the null of model adequacy. We followed Granger and Newbold's (1986, pp. 99–101) recommendation not to rely solely on Q-values to discern model adequacy. Following Andersen, Babula, Hartmann, and Rassmussen (2007) and Andersen, Hartmann, Rassmussen, and Babula (2007), we also tested estimated residuals for a unit root with DF tests, whereby stationary estimated residuals suggest specification adequacy. One rejects the null of nonstationary residuals at the five-percent level when the pseudo-$T\mu$ value is negative and has an absolute value above 2.89. With the

Following Andersen, Babula, Hartmann, and Rasmussen (2007) and Andersen, Hartmann, Rasmussen, and Babula (2007), we apply two well-established VAR econometric tools that are not summarized here (for procedural details, see Sims 1980 and Bessler 1984). First, in order to extensively examine the strength of causal interrelationships among the six variables, we analyze the variables' patterns of forecast error variance (FEV) decompositions. Second, in order to reveal the dynamic workings and interrelationships as well as the implied empirical estimates of market-driving parameters, we analyze the results from simulating the estimated model's impulse-response functions under selected endogenous shocks: a one-time rise in QAPCHINA (Simulation 1) and a one-time rise in PAPCHINA (Simulation 2). More impulse response simulations were undertaken but not reported, as some of these other simulations' results were not statistically acceptable, likely because of the limited monthly 2003–2007 sample. As a result, the reported impulse response simulation results are taken as secondary and supplemental results to the analysis of FEV decompositions that serve as the paper's focus.

Patterns of FEV Decompositions and Selected Impulse Response Simulations: Discussion

Analysis of FEV decompositions is a well-known accounting method for VAR model residuals. An endogenous variable's FEV is attributed to shocks in each endogenous variable, including itself. Analysis of FEV decompositions not only provides evidence of the simple existence of a causal relationship among variables but also illuminates the strength and dynamic timing of such a relationship (Andersen, Babula, Hartmann, and Rasmussen 2007; Andersen, Hartmann, Rasmussen, and Babula 2007). A variable is considered exogenous (endogenous) when large (small) proportions of its FEV are attributed to own-variation and small (large) proportions are attributed to other endogenous variables' movements at a particular (in this case monthly) time horizon (Bessler 1984). FEV decompositions of two or more variables may be added together at a horizon for a collective effect (Babula et. al. 2004). Typically, a variable's FEV is more attributed to own-variation and hence is more exogenous at shorter-run horizons (Andersen et. al. 2007a, b). Patterns of FEV decompositions are summarized in Table 1, with only selected patterns of particular importance or interest examined here.

The quantity of U.S–bound Chinese apparel exports are driven primarily by own-variation, especially at shorter-run horizons, when over 80 percent of QAPCHINA's FEV is self-attributed. Just over 60 percent of QAPCHINA behavior is self-explained at the longer-run horizons. Of secondary importance is own-price, which accounts for up to nearly 14 percent of QAPCHINA's variation. Price of U.S–bound non-Chinese apparel exports (PAPROW) is also important, and explains up to 12 percent of QAPCHINA's behavior. Chinese apparel exports to the U.S. market are highly dependent on own and competing prices: up to about 26 percent of QAPCHINA's behavior is explained collectively by PAPCHINA and PAPROW. This latter point, combined with the second simulation's result (Table 2, described below) whereby a positive PAPCHINA shock elicits a rise in PAPROW, suggests that U.S. consumers treat Chinese and non-Chinese apparel as substitutes. U.S. levels of market substitution among Chinese and non-Chinese apparel appear moderate, however, given the small mutual contributions of each to the other's behavioral explanation in Table 1 and given the moderate positive PAPROW impulse responses to a PAPCHINA shock in Table 2.

Table 1 suggests that U.S–bound apparel exports exert substantial influence on the price and volume of China's purchases of raw U.S. cotton. Movements in the price and quantity of U.S–bound Chinese apparel exports explain up to 13 percent of QUS2CH behavior and up to 23 percent of PUS2CH behavior. Likely due in part to third-country effects, prices and quantities of Chinese and non-Chinese apparel in the U.S. market collectively explain up to about 37 percent of China's purchases of U.S. raw cotton and up to over half (about 55 percent) of movements in the price of U.S. raw cotton exports to China. While Table 1 illuminates evidence that quantities and prices of U.S–bound apparel exports influence U.S. raw cotton exports to China, Table 2's results suggest a lack of such evidence. The two modeled simulation shocks (in QAPCHINA and

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pseudo-Tμ test values negative and ranging in absolute value from 7.1 to 9.0, evidence at the five-percent level strongly rejected the null hypothesis of nonstationary residuals in all six cases.

PAPCHINA) did not elicit statistically non-zero impulses in the price and quantity of U.S. cotton exports to China, and the lack of such significant responses may have arisen from the limited nature of the 2003–2007 sample. Future research would do well to replicate these simulations when more sample observations become available.

Following Andersen, Babula, Hartmann, and Rasmussen (2007) and Andersen, Hartmann, Rasmussen, and Babula (2007), a number of lower-limit elasticity estimates emerge from Table 2's results. Each one-percent rise in QAPCHINA (Simulation 1, Table 2) elicits on average a decline of −0.85 percent in own price and a QAPROW decline of −0.10 percent. The sub-unity absolute level of the latter negative response multiplier indicates modest U.S. substitution among Chinese and ROW apparel products. In Simulation 2, each one-percent rise in PAPCHINA elicits on average a −0.90 percent decline in QAPCHINA. As noted by Andersen et. al. (2007a, b), this −0.9 multiplier emerges from a reduced-form model as a net demand effect over and above countervailing and positive supply adjustments, and while not a demand elasticity, it can be cautiously taken as a lower-limit estimate of an own-price elasticity of U.S. demand for Chinese apparel. The implication here is that U.S. demand for Chinese apparel is likely price-elastic.

Several questions arise from this research report. First, it is generally expected that China's economy and its urban population will continue to grow rapidly. If this occurs as expected, and if the relationship between economic growth, urbanization, and textile demand continues to hold, China may need to increase its supply of raw cotton in order to meet its own demand for textiles (see USDA-FAS 2007, p. 7). China has the option to expand its area of domestic planting dedicated to cotton, but has not appeared inclined to do so. This may be partly explained by the price of food and the resulting choices made by both policy makers and individual farmers to allocate planting area to food rather than to cotton (USDA-FAS 2008, p. 3). The alternative, of course, is for China to increase its reliance on imports raw cotton.

Second, under China's value-added tax (VAT) rebate regime, the textile industry is permitted to import raw cotton under a reduced VAT if such imports are used to produce textiles that are ultimately exported. However, effective July 2007, the Chinese government reduced this VAR rebate (People's Republic of China 2007). And in another change in VAT rebate policy, China's Ministry of Finance announced that as of August 1, 2008, the VAR rebate for many products (including the above-cited VAT on cotton imports) would revert to June, 2007 levels (People's Republic of China 2008). That the Chinese government has altered the VAR rebate policy related to Chinese raw cotton imports twice within a period of about a year may have elicited market uncertainty for Chinese textile-industry agents and U.S. cotton exporters concerning the supply and price of U.S. raw cotton in China.

Finally, 60percent of China's trade surplus is related to textiles, and China again included cotton as one of the pillar industries in its 2003 five-year plan (USDA-FAS 2008, p. 7). So although there have been significant challenges to the cotton/textile sector in China, we can expect the government to continue to support this industry.

Limitations and recommendations for future research are clear. The lack of definitive QUS2CH and PUS2CH impulse responses likely results from the limited 2003–2007 monthly sample data that precluded valid estimation with pre-2003 observations without time-variance of regression estimates. A more desirable model would have included total Chinese cotton exports, although the limited sample would not have supported a larger VAR model due to the already limited degrees of freedom. Finally, future research should revisit all major questions addressed here with an expanded model supported by a larger sample as the available number of sample observations appreciably expands.

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Table 1. Decompositions of Forecast Error Variance.

Horizon and variable	QAPCHINA	PAPCHINA	QAPROW	PAPROW	QUS2CH	PUS2CH
	Percentage of forecast error variance explained by					
QAPCHINA: Chinese apparel exports to the United States						
1	84.05	3.62	0.00	7.84	4.48	0.01
2	80.43	6.19	0.96	7.57	4.44	0.42
6	66.54	13.35	2.28	10.05	5.26	2.52
9	64.55	13.08	3.05	11.44	5.20	2.68
12	63.96	12.97	3.04	12.10	5.27	2.66
18	63.06	13.57	3.02	12.16	5.26	2.93
24	62.70	13.69	3.00	12.20	5.33	3.08
PAPCHINA: Price of Chinese apparel exports to the United States						
1	67.10	18.89	1.23	5.50	6.74	0.54
2	64.61	18.62	2.30	5.69	6.52	2.27
6	57.06	19.16	3.62	9.08	7.45	3.64
9	56.49	18.98	4.19	9.15	7.43	3.77
12	56.22	19.14	4.21	9.11	7.48	3.85
18	56.08	19.17	4.20	9.11	7.53	3.92
24	56.06	19.17	4.20	9.12	7.53	3.92
QAPROW: Non-Chinese apparel exports to the United States						
1	4.04	3.52	79.62	12.53	0.11	0.18
2	9.84	3.55	75.58	10.31	0.57	0.15
6	6.74	9.71	51.08	19.05	10.95	2.47
9	5.83	12.73	43.04	20.20	13.67	4.54
12	5.41	14.79	39.34	19.53	14.88	6.06
18	5.15	16.06	37.02	18.52	15.92	7.34
24	5.14	16.06	36.86	18.60	15.97	7.37

Source: Estimated model simulations by authors.

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Table 1. Decompositions of Forecast Error Variance (Continued).

Horizon and variable	QAPCHINA	PAPCHINA	QAPROW	PAPROW	QUS2CH	PUS2CH
	Percentage of forecast error variance explained by					
PAPROW: Price of Non-Chinese apparel exports to the United States						
1	3.14	13.68	2.71	73.89	6.09	0.49
2	3.06	14.80	2.64	68.08	6.27	5.15
6	4.54	24.22	2.48	50.51	7.29	10.96
9	4.25	27.16	2.17	43.89	9.15	13.38
12	4.15	27.07	2.07	42.74	9.88	14.08
18	4.11	26.97	2.15	42.99	9.85	13.94
24	4.11	27.55	2.15	41.98	9.92	14.30
QUS2CH						
1	1.37	1.66	4.69	0.06	90.25	1.98
2	2.61	1.30	14.70	0.12	76.94	4.34
6	5.04	5.93	16.82	4.31	62.66	5.26
9	5.22	6.20	16.14	6.73	59.51	6.21
12	5.11	6.20	15.81	8.52	58.25	6.11
18	5.11	7.89	15.27	8.90	56.17	6.66
24	5.08	8.32	15.03	9.00	55.55	7.02
PUS2CH						
1	2.11	1.16	8.69	0.49	23.02	64.53
2	2.42	1.06	15.93	1.27	20.70	58.62
6	3.56	3.09	20.94	21.36	15.05	36.01
9	2.97	12.54	17.94	21.40	14.42	30.74
12	2.78	18.49	14.87	18.34	15.73	29.79
18	2.64	20.33	13.26	16.72	17.30	29.74
24	2.65	20.41	13.17	17.04	17.26	29.46

Source: Estimated model simulations by authors.

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Table 2. Dynamic Monthly Aspects of Selected Impulse Response Simulations.

	Reaction times (months)	Direction of responses	Response durations (months)	Multipliers
Simulation 1: Increase in Chinese exports of U.S.-bound apparel.				
PAPCHINA	0	Decrease	1	-0.85
QAPROW	2	Decrease	1	-0.10
PAPROW	NSSR	NSSR	NSSR	NSSR
QUS2CH	NSSR	NSSR	NSSR	NSSR
PUS2CH	NSSR	NSSR	NSSR	NSSR
Simulation 2: Increase in the price of Chinese exports of U.S.-bound apparel.				
QAPCHINA	0	Decrease	1	-0.9
QAPROW	NSSR	NSSR	NSSR	NSSR
PAPROW	1	Increase	1	+0.03
QUS2CH	NSSR	NSSR	NSSR	NSSR
PUS2CH	NSSR	NSSR	NSSR	NSSR

NSSR: no statistically significant impulse responses at the ten-percent level.