US Cotton Exports and Bilateral Exchange Rates[†]

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Abstract
This paper compares the sensitivity of US cotton exports to the bilateral exchange rate for three Asian textile producers with a long series of yearly data from 1978 to 2010. The model of the cotton market includes an alternate supply, US production cost, and local mill use. Effects of each bilateral exchange rate vary considerably across these countries. Aggregation and the related trade weighted exchange rate lead to misleading results. Changes in the rate of depreciation have more robust effects than depreciation, suggesting a wealth effect on cash balances.

Keywords: *Cotton imports, exchange rates*
JEL codes: *Q17, F14, F31*

This paper examines the effects of the bilateral dollar exchange rate on US cotton exports to three Asian textile producers, Bangladesh, Indonesia, and Thailand, in a market model covering 1978 to 2010. US cotton exports to these three developing countries grew considerably even though their currencies generally depreciated relative to the dollar. Other significant importers had fixed exchange rates during the sample period. China has become the largest importer with 30% of US exports in 2008 but exports were inconsistent before liberalization in 2000 and the exchange rate remains fixed. Turkey accounted for 17% of US cotton exports in 2007 but the lira remains fixed relative to the dollar.

The present model of the cotton import market includes an alternate supply insensitive to the dollar exchange rate. Exogenous variables in the market model are US production cost that fell during the sample period, and textile mill use that grew considerably for each of these developing textile producers. Estimates include effects of the Asian financial crisis.

The main conclusion is that exchange rate effects vary considerably across the three importers. Aggregation proves misleading due to an insignificant effect of the relevant trade weighted exchange rate. A novel property is that the rate of depreciation has more robust effects than depreciation itself. An increase in the rate of depreciation lowers the purchasing power of importer cash balances, suggesting a wealth effect not noted in the literature.

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I. A Summary of US Cotton Exports

About half of the cotton produced in the US was exported between1970 and 2000. Between 2000 and 2010 there was an upward trend of about 70%. The US remains the largest cotton exporter in the world accounting for about a fifth of the world total as described by Jolly, Jefferson-Moore, and Traxler (2005). Trends of the dollar exchange rate and the US share of the world cotton market are described by Shane (2001). Similarly, a report by the Cotton Research and Development Corporation (2003) stresses the role of the exchange rate for Australian cotton exports.

Schuh (1974) examines the effects of exchange rates on cotton trade during the Bretton Woods era of fixed exchange rates. Raines (2002) finds only minimal exchange rate impact on US textile trade during the 1990s. Shane, Roe, and Somwaru (2008) find no exchange rate effects on US cotton exports although they do uncover effects for other commodities.

Regarding other commodities, Awokuse and Yuan (2006) find an effect of exchange rate volatility on US poultry exports. Xie, Kinnucan, and Myrland (2009) find exchange rate effects on domestic prices and exports of farmed Salmon from Norway. Almarwani, Jolly, and Thompson (2007) find dollar appreciation between 1961 and 2000 lowers some agricultural exports but with uneven impacts across countries and commodities. Examples of time series analysis of market models similar to the present include Byard, Chen, and Thompson (2007) for NAFTA tomato imports into the US. Copeland and Thompson (2008) examine the link between US wages and falling tariffs. Upadhyaya and Thompson (1998) examine exchange rates effects on Alabama manufacturing.

II. The Import Market Model

The present model of the import market focuses on the effect of the bilateral exchange rate on US cotton exports. In Figure 1 cotton supply X refers to the export supply curve of US as a net exporting country to these three textile producing countries. The model is estimated with variables in natural logs. Cotton supply X is a function of the local currency price converted from the dollar price by the local exchange rate. In natural logs $P = P_{\$} - E$ where P is the log of the local currency price, $P_{\$}$ is the log of the dollar price, and E is the log of the exchange rate. Local currency depreciation (a decrease in E) shifts X to the left with a higher local cotton price P for a given dollar price of cotton. The model includes an alternative source insensitive to the dollar exchange rate. Alternative supply S increases in the local price P but is insensitive to the bilateral dollar exchange rate.

Cotton demand D is the marginal revenue product of cotton in textile production. Quantity demanded decreases in P. Mill use M is an exogenous demand shifter based on the demand for textiles. The suggested log linear demand function for cotton is specified as

$$D = a_0 - a_1P + a_2M + a_3E, \tag{1}$$

where D is quantity of bales demanded.

Signs of parameters indicate expected effects. Depreciation, a decrease in E, lowers the quantity of cotton demanded. Mill use M is an exogenous independent variable with

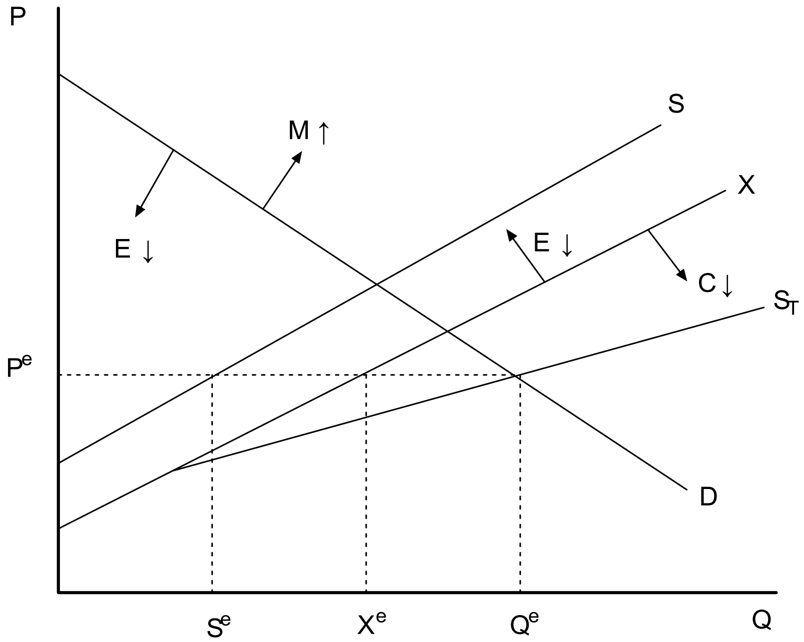

Figure 1. *The market for cotton in the importing country*

a positive effect on the quantity of cotton demanded. Textile producers are assumed to maintain a cotton warehouse, relaxing the strict link between mill use and cotton demand.

The quantity of imports X of US cotton in Figure 1 is specified as a linear function of the dollar price $P_\$ = EP$ as well as the unit production cost C of cotton,

$$X = -b_0 + b_1 P_\$ - b_2C = -b_0 + b_1E + b_1P - b_2C. \quad (2)$$

Alternate cotton supply S is specified as an increasing function of local price,

$$S = -c_0 + c_1P. \quad (3)$$

The market equilibrium quantity of cotton Q^e and price P^e occur where demand D equals total supply $S_T = X + S$. Combine (1), (2), and (3) to derive price as a function of the three exogenous variables,

$$P^e = \overset{(+)}{d_0} + \overset{(?)}{d_1}E + \overset{(+)}{d_2}M + \overset{(+)}{d_3}C, \quad (4)$$

where $d_0 = (a_0 + b_0 + c_0)/\alpha > 0$, $d_1 = (a_3 - b_1)/\alpha$, $d_2 = a_2/\alpha > 0$, $d_3 = b_2/\alpha > 0$, and $\alpha = a_1 + b_1 + c_1$. The effect of E on the market equilibrium price P^e is ambiguous since depreciation lowers supply from the US but also lowers demand. The effects of M and C on P^e are positive.

Substitute the equilibrium price P^e into the US cotton supply function (2) to find the reduced form equilibrium exports X^e as a function of the three exogenous variables,

$$X^e = \overset{(?)}{\alpha_0} + \overset{(+)}{\alpha_1}E + \overset{(+)}{\alpha_2}M + \overset{(-)}{\alpha_3}C, \quad (5)$$

where $\alpha_0 = b_1d_0 - b_0$, $\alpha_1 = b_1(1 + d_1) > 0$, $\alpha_2 = b_1d_2 > 0$, and $\alpha_3 = b_1d_3 - b_2 < 0$. There is a positive exchange rate effect in α_1 since the condition $d_1 = (a_3 - b_1)/(a_1 + b_1 + c_1) > < -1$ reduces to $a_1 + a_3 + c_1 > 0$. Similarly, α_3 is negative.

Demand may also be sensitive to depreciation reducing the purchasing power of local cash balances. Let B represent the natural log of local cash balances. The change in the dollar value of local cash balances is $\Delta E + \Delta B$ where E and B are natural logs. Depreciation diminishes purchasing power in the term ΔE. This reduced purchasing power lowers cotton demand in a wealth effect independent of the reduced quantity demanded. In the present estimates, changes in the rate of depreciation $N \equiv \Delta E$ where E is the log of the exchange rate reveal significant effects. Rates of depreciation N are stationary and highly variable while the exchange rate series E are smooth trends. Replace E with N in (5) to test sensitivity to depreciation,

$$X^e = \alpha_0 + \alpha_1 N + \alpha_2 M + \alpha_3 C. \qquad (6)$$

Summarizing the model, depreciation decreases US exports X^e and local quantity demanded D, lowering cotton consumption Q^e. An increase in the depreciation rate N would have the same effects due to reduced purchasing power of cash balances. An exogenous increase in mill use M increases cotton demand and raises X^e. Lower US production cost C increases US supply resulting in higher X^e.

III. Cotton Market Data

Yearly data begin with the earliest available series on bilateral cotton exports and extend from 1978 to 2010. The three cotton importers are selected due to their floating or at least regularly adjusting exchange rates during the sample period. The three bilateral exchange rates are from *Economic Research Service* of the USDA. Figure 2 indicates the overall depreciations of the Bangladeshi taka, Indonesian rupiah, and Thai baht have different patterns and timings. For the taka, there is consistent depreciation over the three decades that slows in 1986, a smooth trend appearing easy to predict. The rupiah depreciates more steadily but with sharp falls in 1980, 1986, and especially 1996

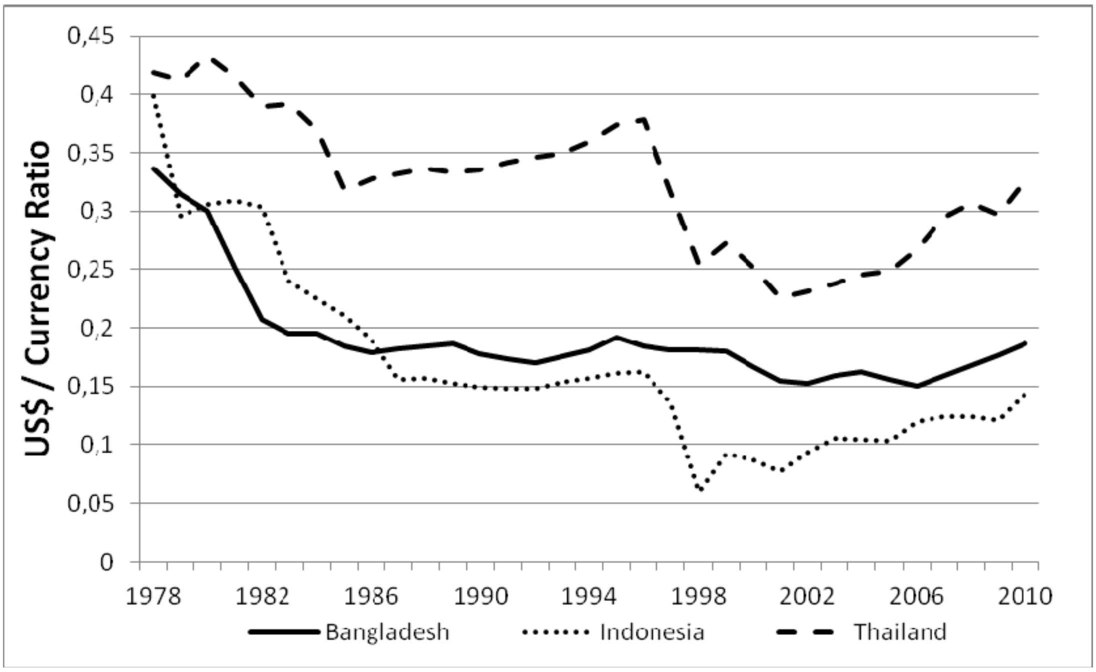

Figure 2. *Exchange Rates*

with the Asian financial crisis. The Thai baht has sharp depreciations in 1980, 1983, and 1996 but is stable aside from those three collapses.

The sharp depreciations are hazardous for textile producers. For example, a mill with a contract to purchase 1000 bales at $1000 per bale would have paid 1,680,000 baht in 1982 but 2,400,000 million after the 30% depreciation in 1983. Even more catastrophic was the baht collapse of 46% in 1996 with the Asian financial crisis. The baht exchange rate might appear the most disruptive but Thai textile producers might more actively avoid exchange risk.

Figure 3 shows the three stationary depreciation rates N with means and standard deviations of –5.2% (5.5%) for Bangladesh, –9.4% (18.4%) for Indonesia, and –1.7% (13.8%) for Thailand. High variability would seem to affect imports more than smooth trends, verified in the present estimates.

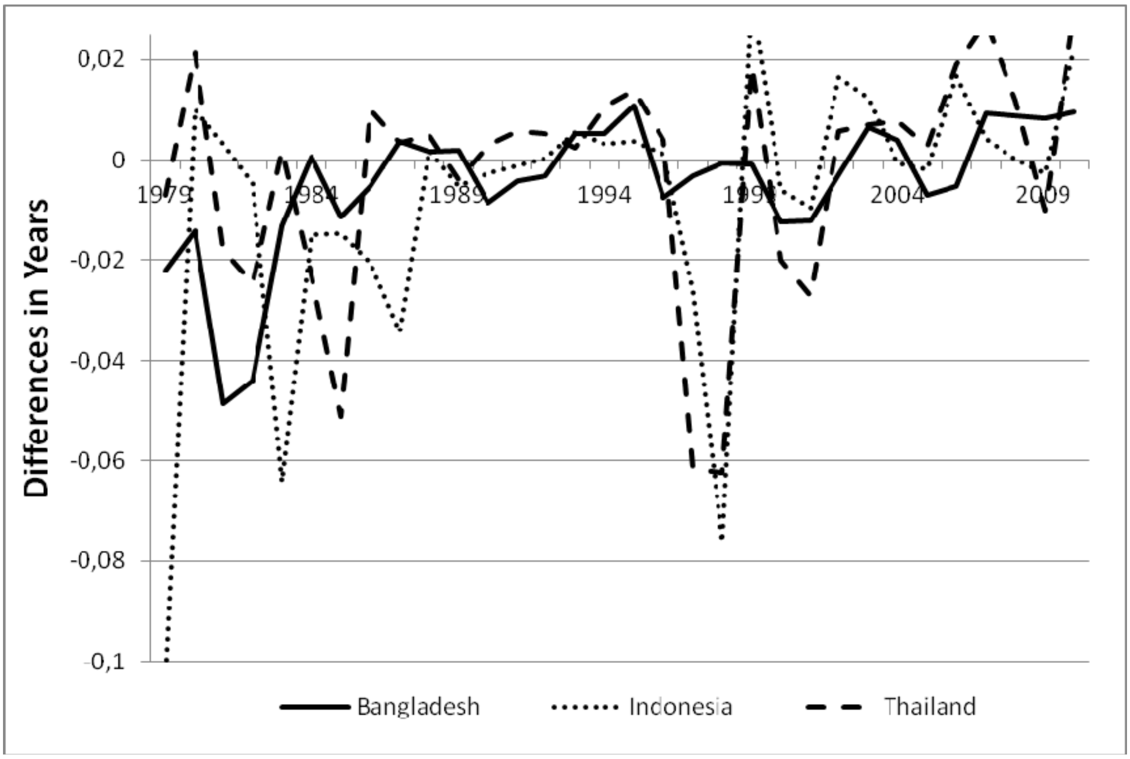

Figure 3. *Depreciation rates N*

Data on bales of cotton imports and local mill use are from the National Cotton Council of America (2010). Figure 4 shows the different export growth patterns to the three textile producers. Exports to Bangladesh are steady with some growth during the 1990s. The sharp falls in 1983, 1989, and 2001 do not appear due to the baht exchange rate that depreciates steadily except for the collapse in 1974.

Indonesia has a more dramatic pattern with periods of rapid growth in cotton imports from the US but a collapse in 1983 coinciding with the rupiah collapse, and other collapses in 1991 and 1994. Collapses of the rupiah in 1980 and 1996 have no apparent effects.

Thailand's imports are stable before beginning to increase in 2000. Baht collapses in 1980 and 1996 occurred during years when imports were declining. The 1983 collapse of the Thai baht is consistent with the subsequent decline in imports.

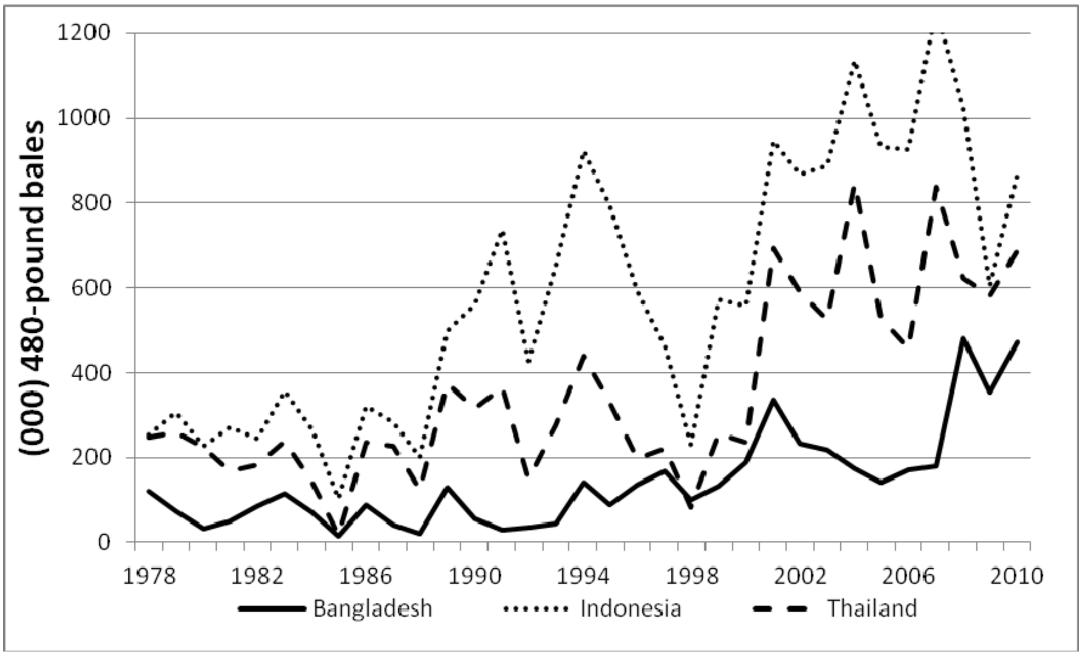

Figure 4. *Cotton exports*

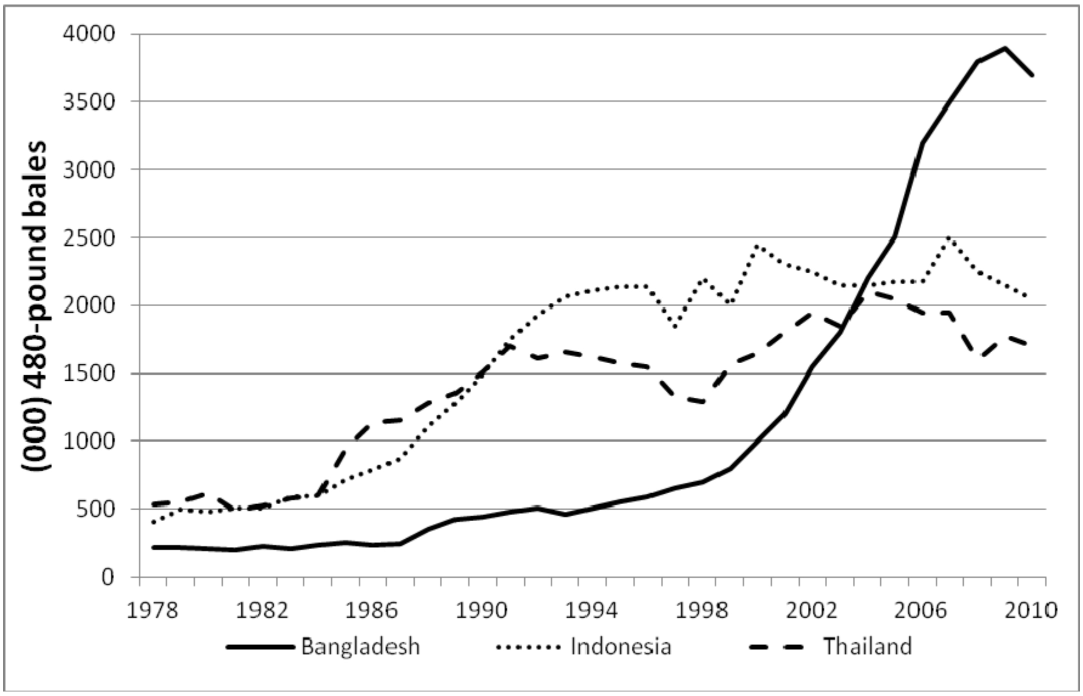

Figure 5. *Mill Use*

The increasing mill use in Figure 5 would raise cotton import demand. Mill use in Bangladesh is level until 1987, then grows steadily until 1999 before growing at a faster rate. Mill use in Indonesia increases in 1986 but falls off in 1993 and becomes erratic. Mill use in Thailand begins a sharp increase in 1984 before entering a period of decline in 1991 that lasts until 1998.

Figure 6 shows US cotton production cost in 2007 cents per bale, the USDA farm price (USDA, 2010). Assuming competitive pricing or constant markup pricing, price equals cost. This falling cost raises US supply in Figure 1 as exports increase.

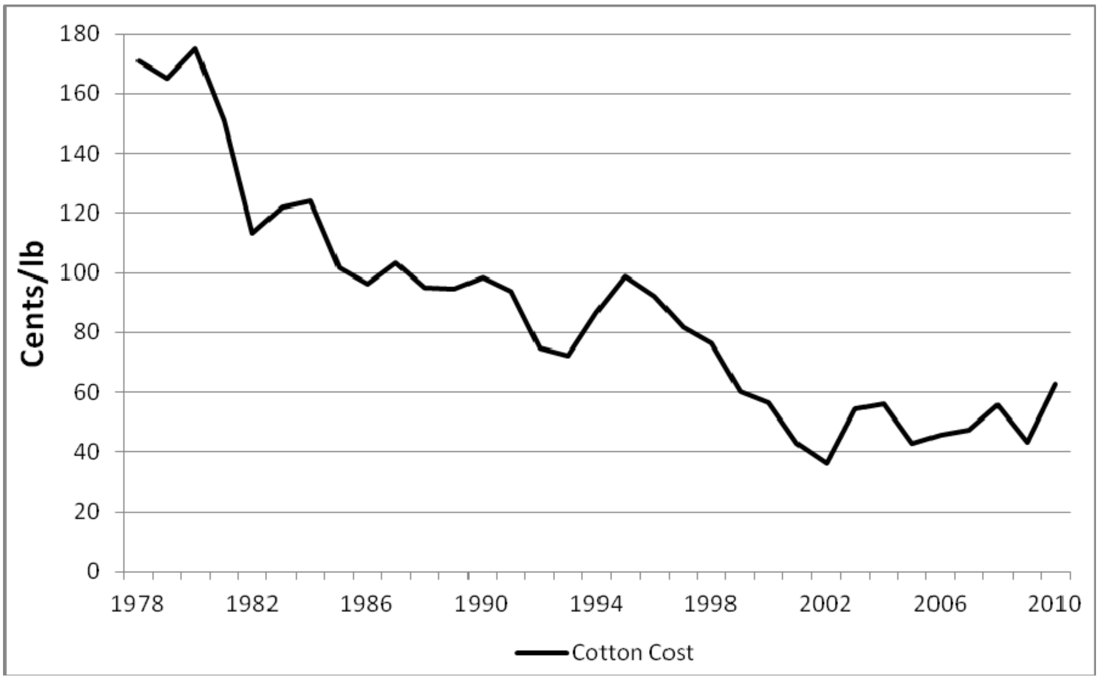

Figure 6. *Unit cost of US cotton*

IV. Empirical Results

a. Stationary Pretests

A preliminary issue is the order of integration of the variables. Ordinary least squares assume variables are stochastic while stationary variables at least tend toward a dynamic equilibrium. Series with the same order of integration may be cointegrated leading to error correction regression that includes adjustment relative to the dynamic equilibrium. All variables are transformed to natural logs. Table 1 reports the three exchange rates are difference stationary by augmented Dickey-Fuller ADF tests. There is no evidence of residual correlation except perhaps for E_B and no evidence of heteroskedasticity. Dif-

Table 1. *Stationarity Analysis*

	E_B	N_B	X_B	M_B
Bangladesh	t = –3.005 ρ = 0.131	t = –3.998 ρ = 0.008	t = –3.056 ρ = 0.117	t = –2.671 ρ = 0.249
	E_I	N_I	X_I	M_I
Indonesia	t = –1.917 ρ = 0.622	t = –6.904 ρ = 0.000	t = –3.252 ρ = 0.074	t = –0.759 ρ = 0.967
	E_T	N_T	X_T	M_T
Thailand	t = –3.645 ρ = 0.026	t = –2.078 ρ = 0.558	t = –2.840 ρ = 0.183	t = –2.877 ρ = 0.170
	C			
US Cotton Cost	t = –2.294 ρ = 0.437			

ferences ΔlnE_t are stationary as suggested by Figure 2. Estimation proceeds based difference stationary exchange rates.

Rates of depreciation N are not difference stationary. Conditional means of depreciation rates from unreported autoregressive processes with a single lag are –5.3% for Bangladesh, –9.7% for Indonesia, and –1.9% for Thailand. The small effect for Thailand is apparent in Figure 1 although the 1996 Asian financial crisis is apparent.

The three cotton export series are difference stationary although the critical statistic for Bangladesh is only marginally significant. Imports into Bangladesh and Thailand are stationary by unreported AR(1) tests as suggested by Figure 4.

Mill use M is difference stationary in Bangladesh and Thailand. The critical coefficient is slightly positive for Indonesia but analysis proceeds assuming the series is difference stationary. US production cost C is difference stationary. The series in (5) may be cointegrated but depreciation rates in (6) are not difference stationary, implying cointegration tests for the exchange rate model (5) but not for the depreciation rate model (6).

b. Estimating the Cotton Export Market Model

The first three rows in Table 2 report estimates with the exchange rate in the model

$$lnX^e = \alpha_0 + \alpha_1 lnE + \alpha_2 lnM + \alpha_3 lnC + \varepsilon, \quad (7)$$

where ε is a white noise residual.

Table 2. *Exchange Rate Model*

	constant	E	M	C	EG –3.60	DW 1.74
X_B	7.25 (1.16)	1.81* (1.70)	0.56** (2.31)	–0.74 (–0.92)	EG –4.31**	R^2 .579 DW 1.82*
X_I	3.75 (1.55)	1.04*** (3.30)	1.03*** (4.53)	–0.69** –(2.38)	EG –4.70***	R^2 .721 DW 2.02*
X_T	13.89** (2.10)	2.26* (1.75)	0.20 (0.43)	–1.62** (–2.26)	EG –3.93*	R^2 .363 DW 1.64*
ECM	**constant**	**ΔE**	**ΔM**	**ΔC**	**γ residual**	
ΔX_B	0.02 (0.15)	–0.29 (–0.14)	0.17 (0.17)	0.31 (0.42)	–0.90*** (–4.82)	R^2 .470 DW 1.87
ΔX_I	0.05 (0.80)	0.99*** (3.04)	0.37 (0.59)	0.04 (0.11)	–0.96*** (–5.41)	R^2 .579 DW 1.85
ΔX_T	0.07 (0.68)	5.09*** (3.49)	–1.03 (–1.24)	–0.96 (–1.46)	–0.92*** (–5.72)	R^2 .605 DW 1.93

The model works best for Indonesia where the exchange rate and mill use have positive effects on imports from US and increased US farm cost discourages local buyers. The Bangladesh and Thailand models have weaker results. While mill use is more important in Bangladesh, cost of cotton discourages local buyers more in Thailand and "gray area" residual correlations discount those effects. The series are cointegrated by Engle-Granger tests suggesting the error correction regressions

$$\Delta lnX^e = \beta_0 + \beta_1\Delta lnE + \beta_3\Delta lnM + \beta_4 ln\Delta C + \gamma\varepsilon_{-1} + e, \quad (8)$$

reported in the following three rows of Table 2. The residual from (7) enters as ε_{-1} in the error correction regression (8).

The error correction regression for Thailand has a strong 5.09 transitory exchange rate elasticitiy β_1. Error correction adjustments are 2.08 = 0.92 x 2.26 for E and –1.49 = 0.92 x –1.62 for cost C with standard errors (0.68) and (0.16) derived by error propagation. The mill use effect is insignificant and discounted by "gray area" residual correlation. For Indonesia, there is also a significant transitory exchange rate effect of 0.96. The associated error correction adjustment implies a significant mill use elasticity of 0.99 (0.23). For Bangladesh there are no transitory or equilibrium adjustments although the error correction coefficient provides evidence the series are cointegrated.

Table 3. *The Asian Financial Crisis in Thailand*

	constant	**E**	**M**	**C**	**D_{97}**	**D_{97}lnE**	**DW 1.93 EG –3.60**
X_T	9.99 (1.61)	7.46*** (3.76)	1.04** (2.18)	–0.92 (–1.28)	–6.22** (–2.41)	–6.11** (–2.75)	R^2 .550 DW 1.89* EG –3.89
ECM	**constant**	**ΔE**	**ΔM**	**ΔC**	**γ residual**		
ΔX_T	0.04 (0.36)	5.17*** (3.43)	0.38 (0.46)	–0.30 (–0.45)	–1.04*** (–5.37)		R^2 .578 DW 2.00

The Asian financial crisis in 1997 led to privatized banking systems. For Thailand, the crisis strongly affects imports as reported in Table 3 where the crisis dummy and its interaction with the exchange rate are significant. Explanatory power almost doubles compared to the model without the crisis dummy variable in Table 2. There is however "gray area" residual correlation. The series are cointegrated leading to the error correction model in the second row. There are no transitory effects in the difference coefficients but the elastic error correction coefficient is $\gamma = -1.04$. These variables robustly adjust relative to the dynamic equilibrium with error correction exchange rate elasticities 1.04 times those in the first row. The derived pre-crisis error correction elasticity for the exchange rate is 7.76 (3.36) while the post-crisis elasticity 0.46 (4.92) is insignificant. The crisis itself leads to a 28.3% decrease in Thailand evaluated at the mean lnE of 3.44 according to $\partial lnX/\partial D_{97} = 1.04 \times [-6.22 + (-6.11 \times 3.44)]$. For Bangladesh and Indonesia, the crisis had no impact on US exports in unreported regressions.

The estimated model for the depreciation rate N in Table 4 is

$$lnX^e = \alpha_0 + \alpha_1 N + \alpha_3 lnM + \alpha_4 lnC + \varepsilon \quad (9)$$

where $N \equiv \Delta lnE$. For Indonesia every unit decrease in N (1% depreciation) lowers exports by 0.80%. This depreciation rate effect is stronger in Thailand lowering exports by 5.37%. As in the previous model, while mill use is more important in Indonesia, cost is more important in Thailand. For Bangladesh there is a hint of a stronger effect. In unreported regressions, the financial crisis dummy and its interaction with N reveal only one significant difference from Table 4 with slightly higher explanatory powers. For Indonesia there is a strong 2.06 depreciation rate effect after the crisis but no effect before the crisis.

The last row of Table 4 reports a strong depreciation rate effect of 2.15 for Thailand based on lags of independent variables. Results for the other two countries with lags are similar to results without lags. An increase of one unit in the depreciation rate lowers exports to Thailand by 2.14% after one year. In an unreported regression, the effect in Thailand is 9.22 before the crisis and 1.73 post-crisis.

Table 4. *Depreciation Rate Model*

	constant	N	M	C	DW 1.74
X_B	–0.90 (–0.23)	–1.75 (–0.83)	0.76*** (3.08)	0.13 (0.23)	R^2 .577 DW 1.74
X_I	2.07 (0.78)	0.80** (2.22)	0.67*** (3.23)	–0.16 (–0.54)	R^2 .669 DW 1.65
X_T	10.83** (2.33)	5.37*** (3.86)	–0.11 (–0.27)	–0.99** (–2.32)	R^2 .555 DW 1.92*
TH with lag	**constant**	N_{-1}	M_{-1}	C_{-1}	
X_T	8.96* (1.79)	1.95 (1.27)	0.19 (0.42)	–1.06** (–2.29)	R^2 .503 DW 2.16

Regressions of the pooled model reported in Table 5 reveal an exchange rate effect and a lagged depreciation rate effect after the crisis. Pooled regressions with the exchange rate, lagged exchange rate, and depreciation rate reveal no effects at all. There are differences in the three countries according to dummy variables in the pooled regressions. Imports into the three countries increased 27% due to the crisis evaluated at the mean N of –5.4%. Some credit for the increased trade must go to the privatized banking systems. The lagged depreciation rate has an elasticity of 1.31 following the crisis, discounted by gray area residual correlation.

Table 5. *Pooled Model*

	constant	E	M	C	D_B	D_I	D_{97}	$D_{97}E$	DW 1.85
X	4.01* (1.67)	0.68* (1.87)	0.50*** (3.75)	–0.31 (–0.92)	–0.32 (–1.39)	1.03*** (3.92)	0.48 (0.84)	0.03 (0.08)	R^2 .721 DW 1.62
	constant	N_{-1}	**M**	**C**	D_B	D_I	D_{97}	$D_{97}N_{-1}$	
X	2.56 (1.23)	0.38 (0.65)	0.47*** (3.40)	–0.10 (–0.33)	–0.68*** (–4.17)	0.55*** (3.95)	0.39* (1.90)	0.37 (0.47)	R^2 .718 DW 1.73*

V. Conclusion

Estimates of the present model of US cotton exports to Bangladesh, Indonesia, and Thailand uncover a strong transitory effect of the bilateral exchange rate in Bangladesh, a hint of a transitory effect in Indonesia, and a strong effect in Thailand before the Asian financial crisis. Textile producers in these countries treat exchange rates differently. Aggregation of the three cotton importers disguises exchange rate effects.

Another critical finding is that the rates of depreciation have stronger effects than exchange rates themselves. An increase in the rate of depreciation not only raises the price of imports but also diminishes the purchasing power of cash balances. For Indonesia this lost wealth is more robust before the Asian financial crisis. For Bangladesh there is a hint of a stronger effect. For Thailand, the effect appears after one year. Banking reforms following the financial crisis weakened these wealth effects.

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