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This paper estimates exchange rate sensitivity since the 1970s of US cotton exports to three textile producers with floating or regularly adjusting exchange rates: Bangladesh, Indonesia, and Thailand. The import market model includes mill use, US production cost, an alternate supply, and the Asian financial crisis. Exchange rate behavior and sensitivity varies considerably across the three importers. Aggregation of the three importers in fact hides market behavior. Changes in the rate of depreciation have stronger effects than depreciation itself.

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

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The Effects of Bilateral Exchange Rates

The present paper examines effects of the dollar exchange rate on imports of US cotton for three textile producers, Bangladesh, Indonesia, and Thailand. The cotton import markets include an alternate supply insensitive to the dollar exchange rate. Exogenous control variables are textile mill use, US production cost, and the Asian financial crisis.

The countries selected are cotton importers with floating or regularly adjusting exchange rates versus the dollar beginning with the earliest country specific export data in 1978 and extending through 2007. Exchange rates are national currencies per SDR from *International Financial Statistics*. Cotton imports and mill use are quantities in bales from the National Cotton Council of America. Production cost is the USDA marketing year average farm price.

Currencies of these three textile producers depreciated during the period: the Bangladeshi taka by 89%, the Indonesian rupiah by 96%, and the Thai baht by 38%. The series differ, however, in timings and patterns suggesting a trade weighted exchange rate might be misleading. Other importers of US cotton had fixed exchange rates for most or all of the sample period. China has become the largest importer averaging 15% of US exports and reaching 30% in 2008. Turkey averaged 7% since 1986 and reached 17% in 2007. Pakistan was the next largest averaging 4% since 2000 and reaching 6% in 2008. China has become the largest international cotton importer but the yuan exchange rate was fixed during the sample period and Chinese imports were not consistent until 2000. Turkey is a large importer as well but is not included because the lira has been fixed with little variation relative to the dollar. China and Turkey have uneven histories and present special cases.

US production cost fell while mill use increased during the sample period. These variables prove essential to the model. US shares of imports average 38% for Indonesia and 29% for both Bangladesh and Thailand during the sample period.

The US remains the largest cotton exporter accounting for about one fifth of world exports as described by Jolly, Jefferson-Moore, and Traxler (2005). Cotton remains a major agricultural commodity in the US Southeast. Shane (2001) describes the trend of the average exchange rate and the US share of the world cotton market but does not present econometric evidence. Similarly, a report by the Cotton Research and Development Corporation (2003) stresses the critical nature of the exchange rate for Australian cotton exports but does not present econometric analysis.

Schuh (1974) examines the effects of exchange rates on cotton trade during the Bretton Woods era of fixed but occasionally adjusting exchange rates. Raines (2002) focuses on the effect of the exchange rate on US textile trade during the floating exchange rates of the 1990s and finds minimal impacts. Shane, Roe, and Somwaru (2008) find no exchange rate effect on aggregate US cotton exports although they do find effects for other commodities.

Regarding other commodities, Awokuse and Yuan (2006) find exchange rate volatility affects 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 lowers some agricultural exports with different impacts across importers and commodities. For cotton they find an exchange rate elasticity of 0.63 for exports to Argentina and 0.34 for Australia with data from 1961 to 2000. Examples of applied time series analysis of related market models include Byard, Chen, and Thompson (2007) on US tomato imports in NAFTA, Copeland and Thompson (2007) on the effect of falling US tariffs on wages, and Upadhyaya and Thompson (1998) on the effects of the exchange rate on Alabama manufacturing industries.

The present paper finds that exchange rate sensitivity varies considerably across the three textile producer markets. Aggregation would be misleading as their trade weighted exchange rate is insignificant. The paper also finds that changes in the rate of local currency depreciation have more robust impacts than depreciation, a novel empirical result that may capture loss of wealth in cash balances.

1. Model of the Cotton Import Market

Cotton supply in the present model comes from the US as well as another source insensitive to the dollar exchange rate. The cotton import market is illustrated in Figure 1. US cotton supply X is an increasing function of the local price P where $P = P_\$/E$, $P_\$$ is the dollar price, and E is the local \$/rupiah exchange rate. Local currency depreciation or a decrease in E shifts X to the left with a higher rupiah price P for a given dollar price. Alternative supply S increases in P but is insensitive to the dollar exchange rate.

* Figure 1 *

Cotton demand D is the marginal revenue product of cotton in textile production and a decreasing function of P. Higher textile prices would increase mill use M, an exogenous demand shifter in the model. Mills use would be exogenous to quantity demanded given warehousing.

The linear demand for cotton is

$$D = a_0 - a_1P + a_2M + a_3E \qquad (1)$$

where D is quantity of bales. Positive parameters indicate the expected effects. Depreciation is a decrease in E that lowers quantity demanded. Mill use is an independent variable that increases quantity demanded under the assumption that textile producers maintain a cotton warehouse.

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

$$X = -b_0 + b_1EP - b_2C = -b_0 + b_1E + b_1P - b_2C. \tag{2}$$

Alternate cotton supply S is a function of local price,

$$S = -c_0 + c_1P. \tag{3}$$

Market equilibrium bales of cotton Q^e and price P^e are found where demand D equals total supply $S_T = X + S$. Combine (1), (2), and (3) to find price as a function of the three exogenous variables,

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

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 P^e is ambiguous since depreciation relative to the dollar 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 imports from the US X^e as a function of the three exogenous variables,

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

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 currency holding B. Profit equals changes in the currency stock, $\Delta B = R - C - (P_\$/E)X - PS$ where R is the revenue from selling textiles and C is local mill expense. The change in its dollar value EB is $\Delta(EB) = E\Delta B + B\Delta E$. Depreciation then has a wealth diminishing effect $B\Delta E < 0$ that lowers cotton demand. This wealth effect independent of the reduction in quantity demanded along the demand curve. Changes in the rate of depreciation $\Delta \ln E$ test this wealth effect. The rates of depreciation N

= -ΔE/E are stationary and highly variable while the exchange rates E have smooth trends. To test market sensitivity to changes in depreciation rates, consider

$$X^e = \alpha_0 + \alpha_1 N + \alpha_2 M + \alpha_3 C. \tag{6}$$

Summarizing, depreciation decreases US supply X and local demand D, lowering cotton consumption Q^e and imports from the US X^e. An increase in the depreciation rate N would have the same effects. An exogenous increase in mill use M increases cotton demand D raising X^e. Lower US production cost C increases US supply X resulting in an increase in X^e.

2. Data Series in the Cotton Import Model

Figure 2 shows the dollar has appreciated relative to the Bangladeshi taka, Indonesian rupiah, and Thai baht but the patterns and timing differ. For the taka exchange rate there is a fairly consistent depreciation over the three decades although the rate slows in 1986. The smooth exchange rate trend appears easy to predict. The rupiah depreciates more steadily than the other two with sharp falls in 1980, 1986, and especially 1996 with the Asian financial crisis but is stable afterwards.

* Figure 2 *

The Thai baht has sharp depreciations in 1980, 1983, and 1996 but is stable aside from those collapses. Such sharp depreciations are difficult on importers with contracts for delivery. An importer with a contract to purchase 1000 bales at $1000 per bale would have paid 1,680,000 baht in 1982 or 2,400,000 million after 30% baht depreciation in 1983, and the baht collapsed 46% in 1996. On the face of the three exchange rates, the baht exchange rate might have been the most disruptive but Thai importers might have done more to avoid their currency.

Figure 3 shows the growth in imports of US cotton for the three importers have different patterns. Imports into Bangladesh are steady with some growth during the 1990s. The sharp falls in

1983, 1989, and 2001 in Figure 2 do not appear to be affected by the baht exchange rate that depreciates steadily except for the 1974 collapse.

* Figure 3 *

Indonesia has a more dramatic import pattern with periods of rapid growth but a collapse in 1983 coinciding with the rupiah collapse, and other collapses in 1991 and 1994. The 1980 collapse of the rupiah has no apparent effect and the 1996 collapse occurs during the sharp decline beginning two years earlier.

Thailand has stable imports before increasing after 2000. Baht collapses in 1980 and 1996 occurred during years when imports fell and the 1983 collapse of the baht is consistent with the subsequent decline in imports from the US.

The increasing mill use in Figure 4 for the three textile producers would increase demand for US cotton. Mill use in Bangladesh is level until 1987 and then grows steadily until 1999 before increasing growth. Mill use in Indonesia increases growth in 1986 but falls off in 1993 and is erratic afterwards. Mill use in Thailand begins a sharp increase in 1984 before entering a period of decline in 1991 that lasts until 1998.

* Figure 4 *

Figure 5 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. This high variability might affect imports more than smooth trending exchange rates, and empirical analysis uncovers this property.

* Figure 5 *

Figure 6 shows the falling US cotton unit production cost in 2007 dollars. The data is cents per bale "farm price" under the assumption of competitive pricing or constant markup pricing. The falling cost per bale would raise US supply in Figure 1 and imports into the three textile producers.

* Figure 6 *

3. Stationarity Analysis

A preliminary question is the order of integration of the variables in reduced form equations (5) and (6). Ordinary least squares regression assumes variables are stochastic while stationary variables at least tend toward a dynamic equilibrium. Variables that are not stationary might be difference stationary and if the series are integrated of the same order they may be co-integrated. The error correction model includes transitory adjustment as well as adjustment relative to the dynamic equilibrium.

Variables are transformed to natural logs. As reported in Table 1 the three exchange rates are difference stationary by the augmented Dickey-Fuller ADF test $\Delta lnE_t = a_0 + a_1 lnE_{t-1} + a_2 t + a_3 \Delta lnE_{t-1} + e_t$ with the critical a_1 variable equal to zero according to the DF statistic and all coefficients equal to zero by ϕ tests. There is no evidence of residual correlation except perhaps for E_B and no evidence of heteroskedasticity implying stochastic differences ΔlnE_t as suggested by Figure 2. Analysis proceeds based difference stationary exchange rates.

* Table 1 *

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 lower change in the depreciation rate for Thailand is apparent in Figure 1 although the Asian financial crisis stands out.

The three cotton imports X series are difference stationary although the critical a_1 statistic for Bangladesh is marginally significant. Imports for 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. For Indonesia the critical coefficient is slightly positive but analysis proceeds assuming difference stationarity. US production cost C is difference stationary. The series in (5) may be co-integrated but depreciation rates in (6) are not difference stationary and co-integration is not tested.

4. Cotton Import Model Estimates

The first three rows in Table 2 report the estimated reduced form equation (5) with the exchange rate as

$$\ln X^e = \alpha_0 + \alpha_1 \ln E + \alpha_2 \ln M + \alpha_3 \ln C + \varepsilon \qquad (7)$$

where ε is a white noise residual. For Bangladesh and Indonesia only mill use has any effect and "gray area" residual correlations may discount those effects. For Thailand the model has very weak results. The series are co-integrated by Engle-Granger tests suggesting the error correction models

$$\Delta \ln X^e = \beta_0 + \beta_1 \Delta \ln E + \beta_3 \Delta \ln M + \beta_4 \ln \Delta C + \gamma \varepsilon_{-1} + e \qquad (8)$$

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

* Table 2 *

The ECM for Bangladesh has a strong 3.61 transitory exchange rate elasticitiy β_1. Error correction adjustments are 0.85 = 0.83 x 1.03 for E and 0.67 = 0.83 x 0.81 for mill use M with standard errors (0.68) and (0.16) derived by error propagation. The exchange rate effect is insignificant and there is "gray area" residual correlation. For Indonesia there is a hint of a transitory exchange rate effect. The associated error correction adjustment implies a significant mill use elasticity of 0.47 (0.23). For Thailand there are no transitory or equilibrium adjustments although the error correction process is significant.

The Asian financial crisis of 1997 privatized the previously government owned banking systems. For Bangladesh and Indonesia the crisis had no impact and regression results are not reported. 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 Table 2. There is "gray area" residual correlation and the series are co-integrated leading to the error correction model in the second row. There are no transitory effects in the difference coefficients but an elastic error correction coefficient $\gamma = -1.28$. These variables robustly adjust relative to the dynamic equilibrium with error correction exchange rate elasticities 1.28 times those in the first row. The derived pre-crisis error correction elasticity for the exchange rate is 9.64 (3.36) while the post-crisis elasticity 0.46 (4.92) is insignificant. The crisis itself leads to a 1.4% increase in Thailand evaluated at the mean lnE of -3.4 according to $\partial \ln X/\partial D_{97} = 1.28 \times [-23.3 + (-7.17 \times -3.4)]$.

* Table 3 *

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

$$\ln X^e = \alpha_0 + \alpha_1 N + \alpha_3 \ln M + \alpha_4 \ln C + \varepsilon \qquad (9)$$

where N is the percentage change $\Delta \ln E$. For Indonesia every unit decrease in N or depreciation by 1% lowers imports by 0.74%. The -9.4% mean depreciation rate and 18.4% standard deviation suggest a range of effects from 7% to -21%. For Bangladesh there is a hint of a stronger effect. For Thailand the model explains no import variation. In unreported regressions the financial crisis dummy and its interaction with N reveal only one significant difference from Table 4 although explanatory powers are slightly higher. For Indonesia there is a strong 2.06 depreciation rate effect after the crisis but no pre-crisis effect.

* Table 4 *

The last row of Table 4 reports a strong depreciation rate effect of 2.15 for Thailand with 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 imports into Thailand by 2.14% after one year. In an unreported regression with the crisis, the effect in Thailand is 9.22 pre-crisis and 1.73 post-crisis.

Regression analysis of the pooled model in Table 5 reveals only a lagged depreciation rate effect post-crisis. Pooled regressions with the exchange rate, lagged exchange rate, and depreciation rate reveal no effects. The countries are different as indicated by dummy variables. Imports for the three countries increased 27% due to the crisis evaluated at the mean N of -5.4%. Some credit for the expanded trade must go to the privatized banking reform. The lagged depreciation rate has an elasticity of 1.31 following the Asian crisis although gray area residual correlation discounts this effect.

* Table 5 *

5. Conclusion

The present cotton import model focuses on the effects of the dollar exchange rate on cotton imports from the US for Bangladesh, Indonesia, and Thailand. The model includes an alternate source of cotton. Control variables are mill use and US cotton production cost. In Bangladesh the dollar exchange rate has a strong transitory effect. Indonesia presents a hint of a transitory exchange rate effect. In Thailand the Asian financial crisis proves critical with a strong exchange rate effect before the crisis that altered behavior of importers in Thailand.

Cotton importers in these three countries react differently to their exchange rate. Aggregating the three importers disguises exchange rate effects. The lesson is that exchange rate effects should be examined for each separate market.

Changes in rates of depreciation have stronger effects than changes in exchange rates in the present sample. A change in the rate of depreciation evidently has a wealth effect discounting cash balances and altering business plans. In Indonesia an increase in the rate of depreciation lowers imports with a more pronounced effect before the crisis. For Bangladesh there is a hint of a stronger effect. Thailand has a stronger depreciation rate effect the following year.

More smoothly adjusting exchange rates in markets free from arbitrary central bank intervention should diminish abrupt changes in rates of depreciation. Thailand provides an example of large sudden depreciations affecting imports and by implication production and income. The Asian financial crisis marked a move away from a government owned banking system. The proper role of the central banks remains a critical issue for the international economy. The present paper reinforces the idea that reliable exchange rates or exchange rate changes are critical for successful international trade in intermediate products.

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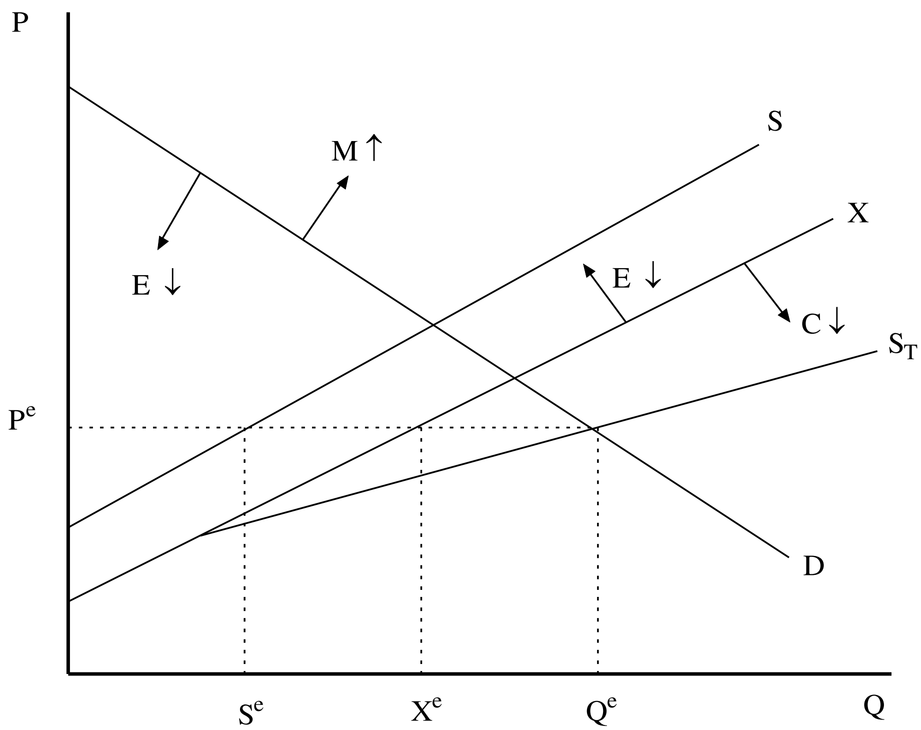

Figure 1. The market for cotton in the importing country

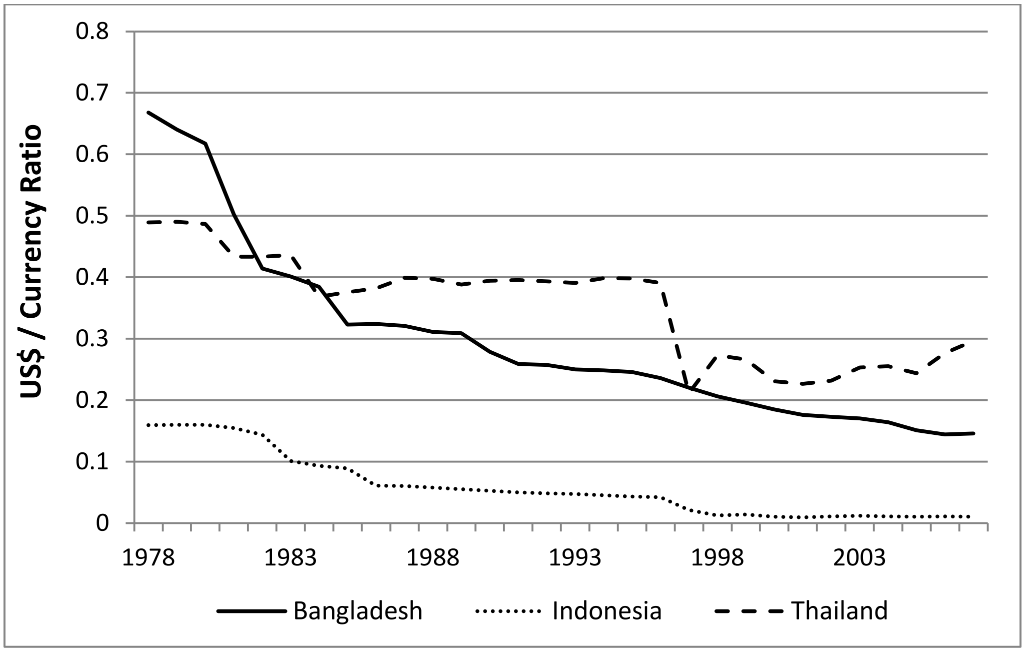

Figure 2. Exchange Rates

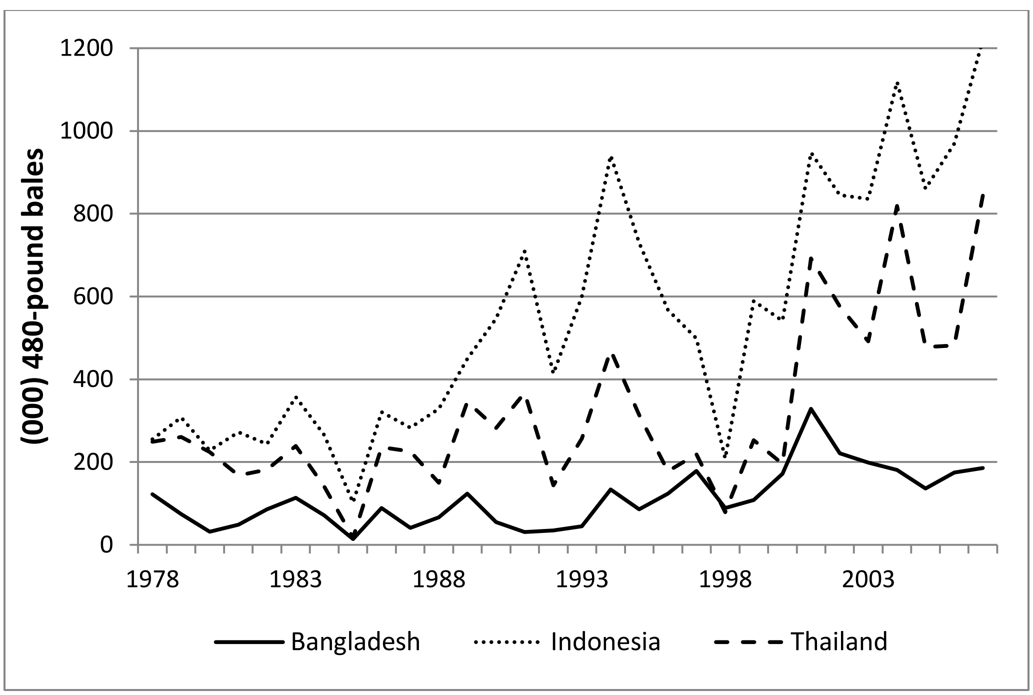

Figure 3. Cotton imports

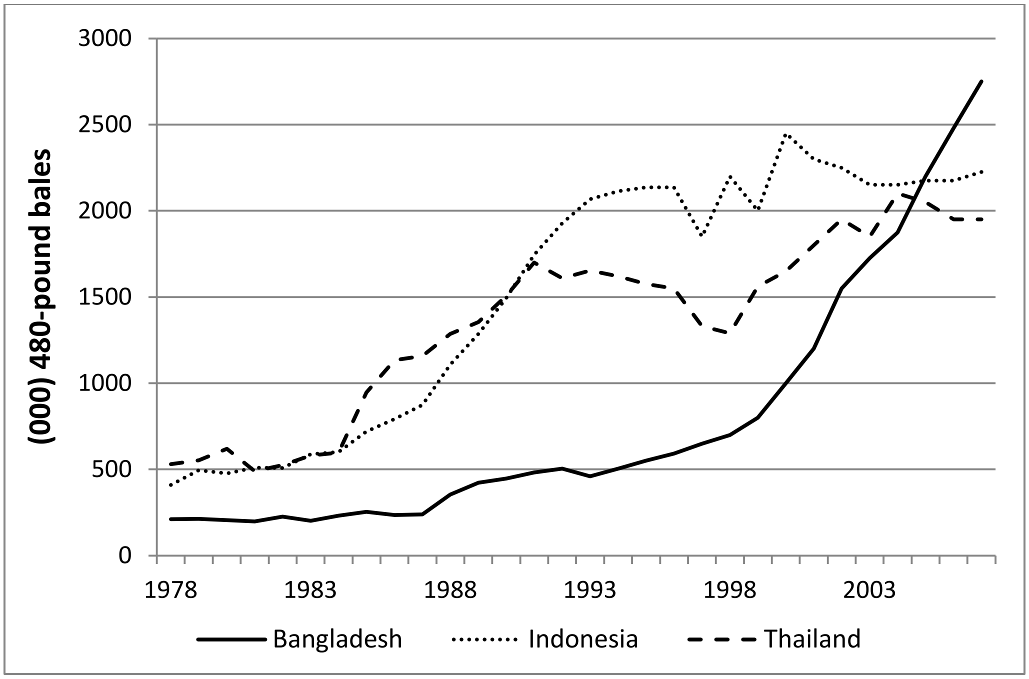

Figure 4. Mill Use

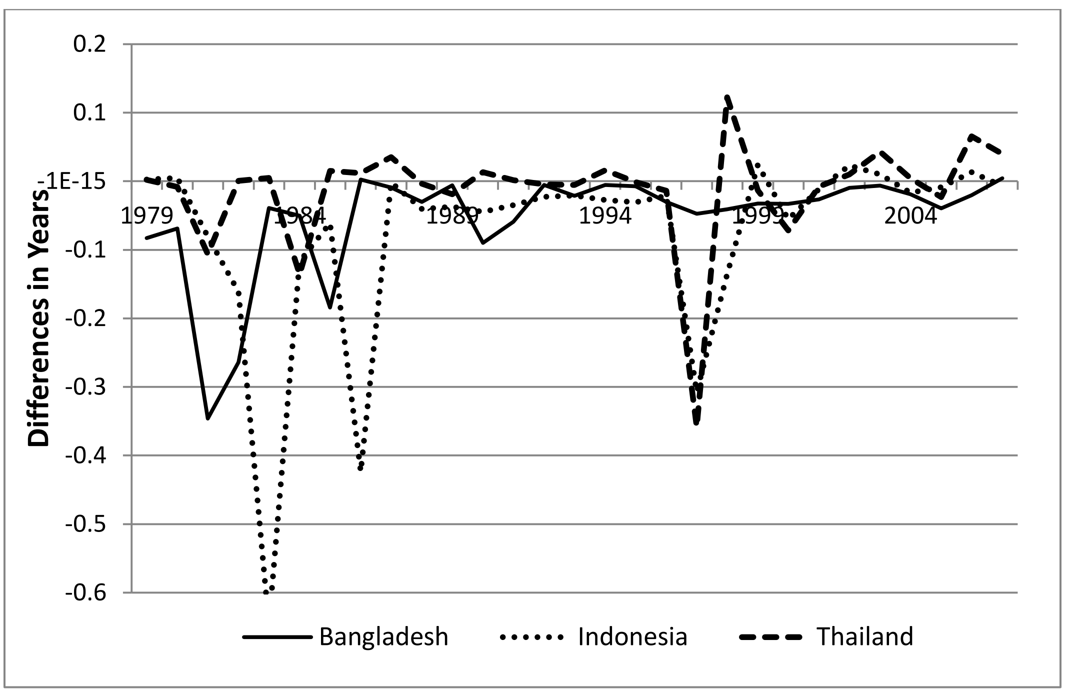

Figure 5. Depreciation rates N

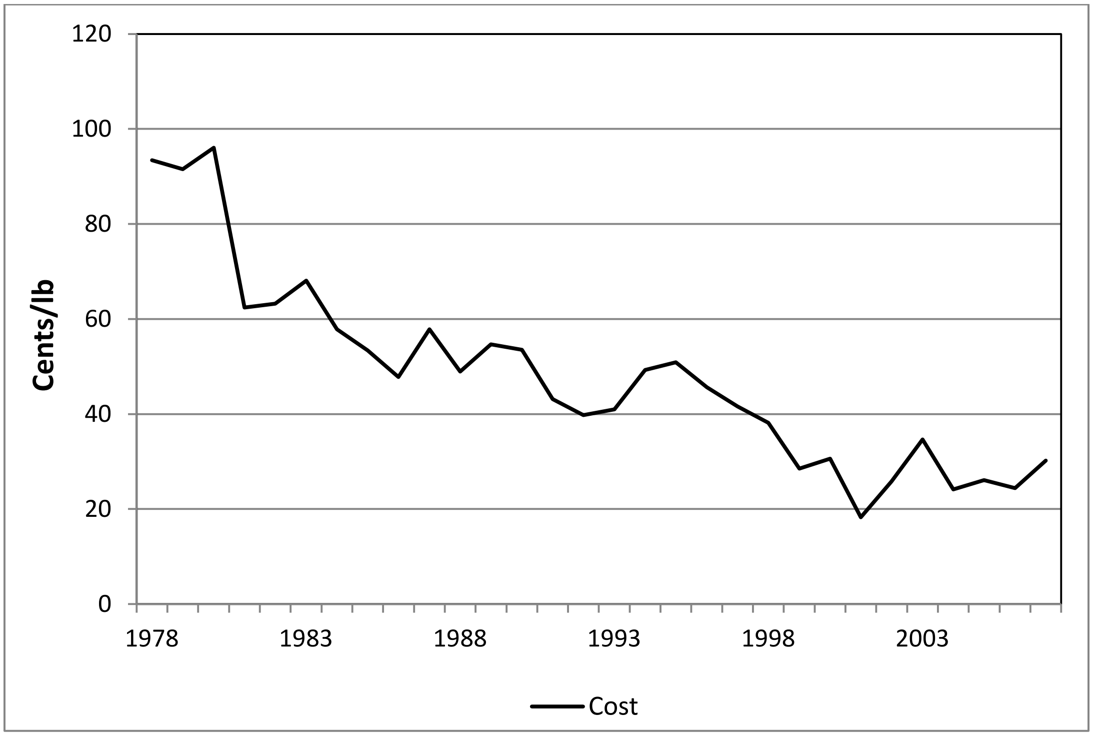

Figure 6. Unit cost of US cotton

Table 1. Stationarity Analysis

	E_B	N_B	X_B	M_B
Bangladesh	t = -3.20 ϕ = 5.38 ρ = .249* ARCH = 0.46	t = -5.00* ϕ = 9.32* ρ = -.202 ARCH = 1.61	t = -3.85* ϕ = 6.35 ρ = .010 ARCH = 0.68	t = -2.06 ϕ = 3.04 ρ = .012 ARCH = -0.33
	E_I	N_I	X_I	M_I
Indonesia	t = -2.32 ϕ = 2.04 ρ = -.017 ARCH = 1.27	t = -3.77* ϕ = 6.55 ρ = .027 ARCH = 1.15	t = -3.01 ϕ = 5.35 ρ = .008 ARCH = -0.55	t = 0.07 ϕ = 1.58 ρ = .157 ARCH = 0.45
	E_T	N_T	X_T	M_T
Thailand	t = -1.97 ϕ = 2.35 ρ = .001 ARCH = -0.13	t = -4.77* ϕ = 15.5* ρ = .015 ARCH = -0.27	t = -3.31 ϕ = 6.46 ρ = -.035 ARCH = -0.34	t = -1.47 ϕ = 1.14 ρ = -.013 ARCH = -0.56
	C			
US Cotton Cost	t = -3.04 ϕ = 4.60 ρ = -.043 ARCH = -0.71			Critical τ -3.60 ϕ 7.24

Table 2. Exchange Rate Model

	constant	E	M	C		DW 1.74 EG -3.60
X_B	5.52 (1.00)	1.03 (1.31)	0.81** (2.55)	-0.52 (-0.74)	EG -4.40*	R^2 .449 DW 1.59* ARCH -0.11
X_I	4.01 (1.01)	0.03 (0.13)	0.57** (2.31)	-0.38 -(0.76)	EG -3.92*	R^2 .597 DW 1.48* ARCH -0.77
X_T	8.01 (0.89)	0.53 (0.51)	0.37 (0.78)	-0.75 (-0.87)	EG -4.34*	R^2 .228 DW 1.63* ARCH -0.57
ECM	**constant**	**ΔE**	**ΔM**	**ΔC**	**γ residual**	
ΔX_B	0.08 (0.50)	3.61* (1.82)	1.18 (1.19)	-0.56 (-1.02)	-0.83*** (-4.20)	R^2 .480 DW 1.69 ARCH 0.38
ΔX_I	0.12 (1.47)	0.57 (1.52)	-0.67 (-0.95)	-0.19 (-0.54)	-0.82*** (-4.83)	R^2 .483 DW 2.28 ARCH -0.43
ΔX_T	0.10 (0.73)	0.58 (0.61)	1.75 (1.59)	-0.21 (-0.33)	-0.96*** (-4.93)	R^2 .501 DW 2.08 ARCH -1.06

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	28.5*** (2.77)	7.53*** (3.21)	0.86* (1.95)	-1.09 (-1.22)	-23.3** (-2.20)	-7.17** (-2.35)	R^2 .469 DW 2.40* ARCH 0.69 EG -6.21*
ECM	**constant**	**ΔE**	**ΔM**	**ΔC**	**γ residual**		
ΔX_T	0.01 (0.10)	0.35 (0.46)	0.17 (0.20)	0.02 (0.03)	-1.28*** (-6.25)		R^2 .667 DW 1.97 ARCH -1.66

Table 4. Depreciation Rate Model

	constant	N	M	C	DW 1.74 EG -3.60
X_B	3.50 (0.84)	2.37 (1.19)	0.40 (1.47)	-0.32 (-0.56)	R^2 .489 DW 1.42* ARCH 0.58
X_I	3.06 (1.01)	0.74* (1.88)	0.62* (2.98)	-0.28 -(0.90)	R^2 .641 DW 1.99 ARCH -0.64
X_T	4.31 (0.75)	-0.06 (-0.06)	0.47 (0.96)	-0.47 (-0.84)	R^2 .248 DW 1.65* ARCH -0.59
		N_{-1}	M_{-1}	C_{-1}	
X_T	4.34 0.91)	2.14** (2.62)	0.52 (1.30)	-0.56 (1.18)	R^2 .501 DW 1.88 ARCH -0.68

Table 5. Pooled Model

	constant	N_{-1}	M	C	D_B	D_I	D_{97}	$D_{97}N_{-1}$	DW 1.85
X	3.19 (1.45)	0.10 (1.22)	0.44*** (2.95)	-0.21 (-0.69)	-0.70*** (3.81)	0.65*** (4.73)	0.34* (1.84)	1.31*** (2.79)	R^2 .737 DW 1.78* ARCH 0.45