Dollar Bloc or Dollar Block: External Currency Pricing and the East Asian Crisis*

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Abstract

This paper provides a quantitative investigation of the East Asian crisis of 1997-99. The two essential features of the crisis that we focus on are a) the crisis was a regional phenomenon; the depth and severity of the crisis was exacerbated by a large decline in regional demand, and b) the practice of setting export goods prices in dollars (which we document empirically) led to a powerful internal propagation effect of the crisis within the region, contributing greatly to the decline in regional trade flows. We construct a model with these two features, and show that it can do a reasonable job of accounting for the response of the main macroeconomic aggregates in Korea, Malaysia, and Thailand during the crisis.

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The last decade has witnessed a series of major macroeconomic crises in emerging market economies. Many of the characteristics of these crises – a sudden reversal of the current account, a big drop in GDP, and a large real exchange rate depreciation, are relatively uniform across crisis episodes. In combination with the sheer size of the crises themselves, this opens up the possibility of understanding crises using the tools of quantitative dynamic general equilibrium theory. A number of recent studies have followed this direction[1]. But some features of crises have been hard to understand in the context of open economy general equilibrium theory. In particular, the magnitude and persistence of crises on output and absorption have not been adequately explained in the models to date.

One of the theoretical problems in providing a macroeconomic account of crises is to explain why very large real exchange rate devaluations fail to have an expansionary impact on the economy through an export boom. This is particularly puzzling in the East Asian crisis of 1997-1999. Despite real depreciations of 60 percent or more, export volumes either fell or stagnated for a year or more in most of the worst hit crises countries. The rapid turn-around in the net external balance in these countries was more than accounted for by a huge collapse in imports rather than a rise in exports.

This paper develops a quantitative dynamic general equilibrium model of the East Asian crisis. We focus on the experience of three of the worst hit countries – Korea, Malaysia, and Thailand. We first provide a quantitative description of the impact of the crisis on macroeconomic aggregates, prices, and exchange rates for these countries. We then develop a simple dynamic multi-country open economy model, which is subjected to `crises'. We represent a crisis as a shock to the country or regional risk-premiums on borrowing. Using a calibrated version of the model, we show that the impact of a crisis shock quite closely resembles the observed effects of the East Asian crisis on our sample of countries, both qualitatively and quantitatively.

A key aspect of our modeling strategy – the main element that allows us to quantitatively account for the scale and persistence of the shock, is to view the East Asian crisis as not simply a capital market shock that hits one country in isolation, but as a widespread jump in the risk premium to a region in which countries are interlinked through trade flows. We show that the large and persistent negative affects of the East Asian crisis occurs as a result of a precipitous drop in trade within the East Asia region. Thus, the East

[1] See for example, Arrelano and Mendoza (2002), Neumeyer and Perri (2001), Cook and Devereux (2004), Mendoza (2001), and Gertler, Gilchrist, and Natallucci (2003).

Asian crisis is seen as a combination of a large external shock, and a powerful propagation mechanism, internal to the region.

Our approach to modeling the crisis is similar to a number of previous papers – we make use of a sticky price open economy macroeconomic framework. But we add to this framework a very specific assumption about price setting of export goods. In our model, all export goods prices are quasi-fixed in terms of US dollars, *even for trade within the region*. Using detailed price data from our sample of East Asian countries, we argue that that this pricing assumption accurately characterizes the response of prices following the crisis, as well as the average behavior of prices over a longer sample period. Previous commentators- e.g. McKinnon and Schnabl (2003), have also emphasized this aspect about East Asian export pricing.

The effect of this assumption about export pricing is to reconcile the above mentioned discrepancy between the observed behavior of net exports in East Asia and the predictions of an devaluation-fueled export boom that underlies most models. In our model, a devaluation of a country does not immediately stimulate net exports through lower export prices abroad, since export prices are temporarily fixed in terms of US dollars. But at the same time, an exchange rate devaluation leads to a big fall in import demand, due to the immediate pass-through of exchange rate changes into imported goods. The key feature of the model however, is that a devaluation of a neighboring country will reduce its import demand for countries within the East Asian region just as much as it affects demand for countries in the rest of the world, even if the countries within the region have themselves devalued. That is, a devaluation of a country does not immediate make its exports more competitive within East Asia, because they are priced in US dollars, and a devaluation of a regional trading partner leads to a big drop in demand for that country's exports, since it leads to an increase in the domestic price of the country's exports.

We refer to this aspect of East Asian export pricing as `Dollar Currency Pricing'. We calibrate our model and simulate its response to a crisis shock when this dollar currency pricing applies, and contrast this with the alternative of `local currency pricing' of exports. We find that with local currency pricing of exports, our calibrated model can reproduce the main qualitative features of the East Asian crisis, but not the quantitative features. But with dollar currency pricing, we can do a good job in providing both a qualitative and a quantitative account of the crisis.

I An Empirical Description of the East Asian Crisis

We first outline the main macroeconomic patterns of the Asian crisis for three countries; Korea, Malaysia and Thailand. These three countries directly experienced a currency and financial crisis with a fairly common set of crisis characteristics as described in the introduction.

The large size of the crisis makes it relatively easy to be precise about the initial timing. Figure 1 illustrates the movement of each economy beginning in the third quarter of 1997. We report results from seasonally adjusted quarterly national income accounts. The real variables examined are GDP, consumption, investment, exports, and imports. The nominal variables examined are the deflators of domestic absorption, exports, and imports. In addition, we illustrate the path of the nominal exchange rate, and the short-term nominal interest rate.

Since these countries were growing quickly in the period before the crisis, it is important to account for the trend paths of the macroeconomic aggregates. We detrend all variables except the exchange and interest rates with a log linear-quadratic trend. We then assume that in the absence of the crisis, each variable would revert back to trend according to an AR(1) process. We estimate the AR(1) process for each de-trended variable on pre-crisis data. Figure 1 shows the difference between each series and their outcomes if they had reverted geometrically back to trend after the 3rd quarter of 1997.

Panels I and J show the response of the US dollar based nominal exchange rate, and nominal interest rates. Both variables are illustrated in the form of deviations from the mean exchange rate in the first half of 1997. In the three crisis countries, each economy experienced a sharp nominal exchange rate depreciation in mid-late1997. The nominal depreciation ranges from 40% for Malaysia, to over 60% for Thailand and Korea. The absorption deflator (Panel F) rises sharply in each case, but by far less than the nominal depreciation, so the nominal depreciation leads to a persistent real depreciation of around 30-40%. Moreover, the initial burst of general inflation quickly reverses in all three crisis countries, and (relative to trend) the move towards deflation exacerbates the persistence of real exchange rate depreciation. In all countries, nominal interest rates rise sharply following the crisis. But this is short lived. By mid 1998, nominal interest rates are below their initial trend, and remain persistently low until the end of the sample.

Panels A-E illustrate the real effects of the crisis. All countries experience a sharp contraction in GDP. In early 1998 GDP was between 10% and 16% below trend for all

countries. The fall in GDP is associated with a 10-20% fall in consumption, and a much larger fall in investment, combined with a sharp improvement in the trade balance. The fall in GDP is persistent for Korea, Malaysia, and especially Thailand.

The fact that GDP falls by much less than absorption for all countries points to a key aspect of the crisis in East Asia – a major improvement in the trade balance occurs in all countries. But the trade balance improvement is due much more to a substantial fall in imports more than to a rise in exports. Imports fall by between 20% and 40% and remained persistently below trend until 2000. Exports, on the other hand, responded in a mixed fashion. While it would be anticipated that a real devaluation of the size experienced in Korea, Malaysia and Thailand would stimulate a substantial boom in exports, exports actually fall below trend in Malaysia and Thailand, and remained essentially unchanged in Korea. About a year after the crisis, an export boom starts up in all countries, and exports are substantially above trend in late 1999.

Why do exports remain so depressed following a substantial real devaluation? Figure 2 gives some further evidence by decomposing exports for all four countries into exports specifically destined for the East Asia region, and exports to the rest of the world (using the same de-trending technique as above). Exports to the rest of the world rises above trend in all countries, albeit slowly. Exports to the East Asia region fall sharply and persistently below trend. This is perhaps not surprising, but it underscores the fact that the East Asian crisis took on the character of a wide regional slump. In the model developed below, we argue that this regional interaction is critical in order to understand the magnitude and persistence of the crisis, and the inability of even very large devaluations to expand aggregate demand in these economies.

How important is intra-regional trade in East Asia? Table 1 shows the fraction of exports to Asia as a percentage of exports to Asia plus EU, North America, and Japan, where in addition to our three countries we include Singapore, Indonesia, the Philippines, and Taiwan. With the exception of Indonesia, the share of regional exports was growing for all countries through the 1990's. In 1996, all countries except the Philippines had an excess of 40 percent of exports going to the Asian region. This share had fallen quite sharply by 1998 (again with the exception of the Philippines), but more recently has grown strongly, and now exceeds the levels of the mid 1990's. These figures again suggest that it may be important to allow for regional trade effects when accounting for the East Asia crisis.

While the region-wide recession represented one factor for the slow response of aggregate exports following the large devaluation, the behavior of export prices is another

important element. Figure 1 shows the effects of the crisis on the export and import prices for Korea, Malaysia and Thailand, relative to their pre-crisis trend (panels G and H). In the wake of the sharp devaluation, *both* import and export price deflators rise sharply. Hence, there is high exchange rate pass-through (as documented in Burstein et al 2003) into import prices, but *also* into export prices. Figure 3 shows the changes in import and export prices at the monthly frequency, from February 1997 to the end of 1998, for Korea and Thailand[2]. There is a very close correspondence between monthly changes in the US dollar exchange rate and prices of both imports and exports. For comparison, Figure 3 also shows the same data for Singapore. While the movements in the exchange rate were significantly less, and there is a much weaker association between the exchange rate and import prices, there seems to be substantial pass-through of exchange rate movements into export prices.

The behavior of export and import prices has an important implication for the way in which traded goods prices in Asia are set, and the effects of exchange rate changes in our model. A central characteristic of our model is that both export and import good prices for each emerging economy are quasi-fixed in US dollars. We refer to this as `Dollar Currency Pricing'. That the US dollar is the most important currency for international trade is widely acknowledged. In Asia particularly, MacKinnon and Schnabl (2003) emphasize the central role of the US dollar in both goods and financial markets. Some evidence for dollar currency pricing is given in Table 2. This reports the currency of trade invoicing for exports and imports for Korea and Thailand. For Korea in the mid-1990's 80 percent of industrial imports, and almost 90 percent of exports were invoiced in US dollars. In Thailand in 1997, US dollar invoicing covered 80 percent of imports and 92 percent of exports. Since the US share in total exports for both countries is only about 22 percent, and the US import share is lower, the US dollar clearly plays a disproportionate role in trade pricing. The striking feature of Table 2 is the fact that the local currency has only a tiny weight in either import or export currency invoicing. In particular, for Thailand in 1997, only about 2 percent of exports and imports were invoiced in Thai baht[3]. Indirect evidence on the role of the US dollar as an export currency is given in MacKinnon and Schnabl (2003), and Australian Business Survey (1998). Over 70 percent of Japan's imports from Asia in the mid 1990's were US dollar invoiced, while less than 25 percent were invoiced in yen. Asian currency invoicing (besides yen) of Japanese imports from Asia is essentially non-existent. Similarly,

[2] To date, we have not been able to obtain monthly data on import and export prices for Malaysia.
[3] More detailed evidence for Thailand indicates that substantial Baht export invoicing is used only for smaller ASEAN countries, in particular Laos, Cambodia, and Myanmar.

Australian imports in 1997 were denominated overwhelmingly in US dollars, Australian dollars, or Japanese yen. Other Asian currencies besides yen represented less than 2 percent of Australian import currency invoicing.

Invoicing data alone do not establish that prices are sticky in the invoicing currency, since it is not automatically true that the contractual price and the invoicing price of a traded good are in the same currency. For instance, a Korean car sold to the US could have its contractual price pre-set in Won, and its official US dollar invoicing price adjusted in response to changes in the exchange rate. But this seems inconsistent with the evidence shown above that local currency prices of imports and exports closely reflect movements in the US dollar exchange rate.

More support for the assumption of dollar currency pricing may be gleaned from a detailed study of Korean export and import pricing. Figure 4 illustrates Korean aggregate export prices separately on a won basis, and a US dollar basis, as reported by the Bank of Korea. As shown above, export prices in won jumped dramatically after the depreciation in December 1997 and January 1998. By contrast, prices on a US dollar basis changed hardly at all in the short run. However, over the succeeding year, US dollar prices fell persistently. This is in accord with the pricing mechanism in our model. Exporters set prices in US dollars, and only gradually adjust them in responses to exchange rate changes. The model predicts that, following a crisis generated by a rise in the world risk premium, US dollar prices will remain unchanged in the short run, but will gradually fall as exporters adjust their prices in response to lower real domestic marginal costs. This pattern seems to occur in Figure 4.

Table 3 further breaks down the price adjustment of Korean exports by individual categories of goods. The Table shows the percentage change in the average price, by category, between the four months prior to November 1997, and the four months after November 1997. Measured on a won basis, the price rise is very large for all goods except *other metal products* . On a dollar basis, most prices fall, but by much less than the rise in the won price.

Of course, during the crisis, East Asian exchange rates depreciated not just against the US dollar, but against all other major currencies. Hence, export and import prices are likely to be much more stable measured in any currency, relative to the local currency. But in general, while domestic export and import prices in these economies are very sensitive to the US dollar exchange rate, they are less sensitive to movements in other bilateral exchange rates. Table 4 shows the results of a regression of monthly changes in export and import

prices indices for Korea and Thailand on monthly changes in bilateral exchange rates for the US dollar, the Japanese yen, the euro, and the pound sterling[4]. This can be interpreted as a simple-minded `pass-through' regression on import and export prices. The coefficient on the US dollar is large and highly significant for import and export prices in both countries. In Korea, the yen is significant, but with much lower coefficient value, while the yen is marginally significant for import prices but not export prices in Thailand, with a very small coefficient. Note in particular that the `pass-through' of US dollar exchange rate changes to export prices is higher than that for import prices, in both countries. This provides some further evidence of our dollar currency pricing hypothesis for East Asian export goods.

[4] For pre-1997 data, we use the bilateral d-mark exchange rate instead of the euro.

II The Model

The model consists of two small open emerging market economies, Korea and Thailand, which interact with a larger, developed world through trade in goods and a single risk-free bond[5]. The currency of the developed world is called the dollar. In the baseline model, all international transactions are denominated in dollars, even those between agents in Korea and Thailand. We will then contrast that with an alternative `local currency pricing' assumption, where prices of export goods are set in the currency of the importing country. The prices of goods produced in the developed world are exogenous the emerging market economies. Within the two emerging market economies, households consume, work, and accumulate capital, firms produce a range of country specific goods which are sold to domestic consumers, to the developed world, and to the other emerging market economy. Firms set prices in advance, and adjust them gradually. Finally, monetary authorities in each economy follow an interest rate rule.

A. The Developed World

The developed world produces goods which are available in unlimited quantities to Korea and Thailand at a dollar price P_t^D. The developed world has an iso-elastic demand for goods from Korea and Thailand given by:

$$X_t^{D,j} = s_{D,j}.s_{D,EA}\left(\frac{P_{t,\$}^j}{P_t^{EA,D}}\right)^{-\gamma}\left(\frac{P_t^{EA,D}}{P_t^D}\right)^{-\phi} A_t^D \qquad (0.1)$$

where A_t^D is total absorption of the developed world, $X_t^{D,j}$ is the exports of country j to the developed world, $P_{t,\$}^j$ is the dollar price of the exports of country j, $P_{t,}^{EA,D}$ represents the dollar price of East Asian exports to the developed world, the parameters γ and ϕ are the

[5] This structure was developed in Corsetti et al. (2000) also.

elasticities of demand for each individual East Asian country good, and for East Asian exports in general, and finally, $s_{D,j}$ and $s_{D,EA}$ represent share parameters.

International financial markets provide funds to each country at an exogenous interest rate, $1+r_t^{EA,j}$. Interest rates may be country-specific due to the fact that there are country-specific debt sensitive risk premia, which we define below. We also allow for an exogenous risk premium shock that affects $r_t^{EA,j}$.

B.Households

Each small economy, *j = {Korea, Thailand}* is populated with a continuum of worker-households that accumulate capital and international debt and own local firms. The agent issues dollar denominated debt, D_t, at a dollar interest rate $1+r_t^{EA,j}$ (taken as exogenous by the agent) and domestic currency debt, B_t, at nominal interest rate $1+i_t^j$. Capital K^j and labor H^j is rented to firms in competitive markets at rates *R* and *W* respectively. The agent receives profits, *Π,* from monopolistically competitive firms. Agents purchase final goods at price P^j and allocate goods to consumption, C^j and investment, I^j. Lump-sum taxes finance government spending, G^j. Define S^j as the spot exchange rate (the price of US dollars). The budget constraint is:

$$\begin{aligned} &S_t^j D_t^j + B_t^j \\ &= (1+r_{t-1}^{EA})S_t^j D_{t-1}^j + (1+i_{t-1}^j)B_{t-1}^j + P_t^j\left[C_t^j + I_t^j + G_t^j\right] - \left(W_t^j H_t^j + R_t^j K_t^j + \Pi_t^j\right) \end{aligned} \tag{0.2}$$

Capital accumulation is determined by the condition:

$$K_{t+1}^j = (1-\delta)K_t^j + I_t^j - \frac{\Phi_K}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t$$

where the household faces adjustment costs of changing capital that depends on the rate of change of investment.

The infinitely lived households preferences maximize discounted utility, defined by:

$$E_t U_t = E_t \sum_{j=t}^{\infty} \beta^t \cdot \left\{ \ln(C_t^j - hC_{t-1}^j) - \Gamma H_t^j \right\} \tag{0.3}$$

Households display `habit persistence' with respect to consumption.

B. Imports

The final goods absorbed by the small economy, X_t^j are a CES function of goods produced within the East Asian region $X_t^{EA,j}$ and goods imported from the developed economy (which is the rest of the world):

$$C_t^j + I_t^j + G_t^j = X_t^j = \left[a^{-\frac{1}{\phi}} \left\{ X_t^{j,EA} \right\}^{1-\frac{1}{\phi}} + (1-a)^{-\frac{1}{\phi}} \left\{ IM_t^{j,D} \right\}^{1-\frac{1}{\phi}} \right]^{\frac{1}{1-\frac{1}{\phi}}} \tag{0.4}$$

Goods absorbed from East Asia are themselves a CES function of goods produced in each country:

$$X_t^{j,EA} = \left[b^{-\frac{1}{\gamma}} \left\{ X_t^{j,KR} \right\}^{1-\frac{1}{\gamma}} + (1-b)^{-\frac{1}{\gamma}} \left\{ X_t^{j,TH} \right\}^{1-\frac{1}{\gamma}} \right]^{\frac{1}{1-\frac{1}{\gamma}}}. \tag{0.5}$$

where KR and TH stand for Korea and Thailand, respectively.

C. Production

The economy produces value added using capital and labor with a Cobb-Douglas technology.

$$Y_t^j = \left\{ K_t^j \right\}^{\theta} \left\{ H_t^j \right\}^{1-\theta} \tag{0.6}$$

Capital and labor are rented from households in competitive markets. Producers sell their output in a competitive price to exporters and retailers at a price, MC_t^j. Factor prices are determined by the conditions:

$$MC_t^j \theta \frac{Y_t^j}{K_t^j} = R_t^j, \qquad MC_t^j (1-\theta) \frac{Y_t^j}{H_t^j} = W_t^j.$$

D. Sticky Prices

Each of the three categories of demand for domestic goods, $X_t^{D,j}$, $X_t^{KR,j}$, $X_t^{TH,j}$ are Dixit-Stiglitz indices of goods provided by a unit range of domestic retailers or exporters indexed by i. Define the index *l = D,KR,TH.* We define the quantity aggregator $X_t^{l,j}$ and prices $P_t^{l,j}$, as well as the demand curve for each individual retailer

$$X_t^{l,j} = \left[\int_0^1 \left\{x_{t,i}^{l,j}\right\}^{1-\frac{1}{\xi}} di\right]^{\frac{1}{1-\frac{1}{\xi}}} \qquad P_t^{l,j} = \left[\int_0^1 \left\{p_{t,i}^{l,j}\right\}^{1-\xi} di\right]^{\frac{1}{1-\xi}} \qquad \frac{x_{t,i}^{l,j}}{X_t^{l,j}} = \left(\frac{p_{t,i}^{l,j}}{P_t^{l,j}}\right)^{-\xi} \tag{0.7}$$

In the case of domestic demand (*l = j*), Retailer *i* buys materials at the competitive price MC_t^j and earns profits $\widetilde{\Pi}_{t,i}^{l,j} \equiv \left(p_{t,i}^{l,j} - MC_t^j\right) \cdot x_{t,i}^{l,j}$. Retailers receive an opportunity to change prices with a fixed randomly distributed probability $0 \le (1-\kappa) \le 1$ as in Calvo (1983) and Yun (1996). If they do adjust their prices, they must set the price for period *t* before the beginning of the period (as in Rotemberg and Woodford, 1997).

The domestic retailer maximizes the discounted sum of profits

$$\begin{aligned} &\max_p E_{t-1}\left[\sum_{m=t}^{\infty}\left(\prod_{n=t}^{m}\frac{\kappa}{(1+i_n)}\right)\Pi_{m,i}^{j,j}\right] = \\ &\max_p E_{t-1}\left[\sum_{n=t}^{\infty}\left(\prod_{n=t}^{m}\frac{\kappa}{(1+i_n)}\right)\left\{P_m^{j,j}\right\}^{\xi} X_m^{j,j}\left\{\left\{p_{t,i}^{j,j}\right\}^{1-\xi} - \left\{p_{t,i}^{j,j}\right\}^{-\xi} MC_m^j\right\}\right] \end{aligned} \tag{0.8}$$

The optimal price follows the dynamics:

$$p_t^{l,j^*} = \frac{1}{\xi}\frac{E_{t-1}\left[\sum_{m=t}^{\infty}\left(\prod_{n=t}^{m}\frac{\kappa}{(1+i_n)}\right)\left\{P_m^{l,j}\right\}^{\xi} X_m^{l,j} MC_m^j\right]}{E_{t-1}\left[\sum_{m=t}^{\infty}\left(\prod_{n=t}^{m}\frac{\kappa}{(1+i_n)}\right)\left\{P_m^{l,j}\right\}^{\xi} X_m^{l,j}\right]} \qquad l = j \tag{0.9}$$

Both the exporters to the other Asian economy (*j = l*) and the developed world are priced in dollars. Profits in terms of domestic currency for (l≠*j, l=D)* are given by

$$\widetilde{\Pi}_{t,i}^{l,j} \equiv S_t^j \cdot \left(p_{t,i}^{l,j} - MC_t^j \Big/ S_t^j\right) \cdot x_{t,i}^{l,j}.$$

The retailers selling to the external buyers maximize expected profits as follows:

$$\max_{p} E_{t-1}\left[\sum_{n=t}^{\infty}\left(\prod_{n=t}^{m}\frac{\kappa}{(1+i_n)}\right)S_m^j\left\{P_m^{l,j}\right\}^{\xi}X_m^{l,j}\left\{\left\{p_{t,i}^{l,j}\right\}^{1-\xi}-\left\{p_{t,i}^{l,j}\right\}^{-\xi}MC_m^j\Big/S_m^j\right\}\right] \quad (0.10)$$

$$p_t^{l,j^*}=\frac{1}{\xi}\frac{E_{t-1}\left[\sum_{m=t}^{\infty}\left(\prod_{n=t}^{m}\frac{\kappa}{(1+i_n)}\right)\left\{P_m^{l,j}\right\}^{\xi}X_m^{l,j}MC_m^j\right]}{E_{t-1}\left[\sum_{m=t}^{\infty}\left(\prod_{n=t}^{m}\frac{\kappa}{(1+i_n)}\right)S_m^j\left\{P_m^{l,j}\right\}^{\xi}X_m^{l,j}\right]} \quad (0.11)$$

In each case, aggregate prices follow the adjustment process:

$$\left\{P_t^{l,j}\right\}^{1-\xi}=\kappa\left\{P_{t-1}^{l,j}\right\}^{1-\xi}+(1-\kappa)\left\{p_t^{l,j^*}\right\}^{1-\xi} \quad (0.12)$$

The consumer (or absorption) price index in country *j* is then defined as

$$P_t^j=\left(a\left(P_t^{EA,j}\right)^{1-\phi}+(1-a)\left(S_t^jP_t^{IM,j}\right)^{1-\phi}\right)^{\frac{1}{1-\phi}}$$

while the East Asian price index for country *j* is:

$$P_t^{EA,j}=\left(b\left(P_t^{KR,j}\right)^{1-\gamma}+(1-a)\left(S_t^jP_t^{TH,j}\right)^{1-\gamma}\right)^{\frac{1}{1-\gamma}}$$

E. Interest Rates

Dollar interest rates in Asia are the sum of dollar interest rates in the rest of the world, r_t, a country premium, cp_t^j, and an exogenous regional premium, rp_t.

$$r_t^{EA}=r_t+cp_t^j \qquad cp_t^j=cp+\frac{1}{1-\upsilon}\left(D_t^j-\bar{D}^j\right)^{1-\upsilon}+rp_t \quad (0.13)$$

The regional premium follows an AR(1) process.

$$rp_t=\rho rp_{t-1}+\varepsilon_t \quad (0.14)$$

Domestic interest rates are sent according to an inflation-targeting interest rate rule, with some weight given to exchange rate stability:

$$1+i_t=1+i\left\{\frac{P_t^j}{P_{t-1}^j}\right\}^{\lambda_p}\left\{\frac{S_t}{S_{t-1}}\right\}^{\lambda_s} \quad (0.15)$$

This rule represents a reasonable description of monetary policy in the post-crisis East Asia period. In the crisis countries, the previous exchange rate pegs had been abandoned. What followed the pegs evolved into the current practice of inflation targeting in Korea and Thailand. But, as shown in Figure 1, nominal interest rates rose sharply in the post-crisis period, probably reflecting some concern with limiting the extent of exchange rate depreciation. Hence both inflation stability and exchange rate stability seem to be separate concerns of the monetary authorities.

F. Equilibrium

Define Ξ_t as the history of the economy up to time t. An equilibrium is a set of policy functions of the representative agents, manufacturers and price setters: $C^j(\Xi_t)$, $I^j(\Xi_t)$,), $X(\Xi_t)$, $X^T(\Xi_t)$, $X^N(\Xi_t)$, $X^{Td}(\Xi_t)$, $EX(\Xi_t)$, $IM(\Xi_t)$, $Y^T(\Xi_t)$, $Y^N(\Xi_t)$, $M(\Xi_t)$, $H(\Xi_t)$, $H^T(\Xi_t)$, $H^N(\Xi_t)$, $D(\Xi_t)$, $K^T(\Xi_t)$, $K^N(\Xi_t)$, $w^T(\Xi_t)$, $w^N(\Xi_t)$, $p^T(\Xi_t)$, $p^N(\Xi_t)$, $p^{\$T}(\Xi_t)$; and price functions: $P(\Xi_t)$, $P^T(\Xi_t)$, $W(\Xi_t)$, $R^T(\Xi_t)$, $R^N(\Xi_t)$, $PPI^T(\Xi_t)$, $PPI^N(\Xi_t)$, $S(\Xi_t)$, $i(\Xi_t)$; which solve the first-order conditions of the agents' optimizations problems and labor and goods markets clear.

$$\int_0^1 x_{t,i}^{ROW,j}di + \int_0^1 x_{t,i}^{j,j}di + \int_0^1 x_{t,i}^{l\neq j,j}di = Y_t^j \qquad j = TH, KR \qquad (0.16)$$

III Calibration

A log-linear version of the model is solved using the algorithm in King and Watson (2001) . Some parameters are fairly standard from the open-economy macro literature. The depreciation rate is set at δ=.025 and the discount rate is calibrated as in Backus Kydland and Kehoe, β= .99. We estimate the elasticity of substitution between goods equal to $\phi = \psi = \gamma =$ ⅔ based on some estimates for East Asia by Reinhart (1995).

Cook and Devereux (2004) calculate some of the great ratios for Korea and Thailand. We calibrate our symmetric model using averages of the parameters for those two countries. We set the ratio of exports in GDP at .301. Government as a share of GDP is .106. We set the ratio of steady-state external debt to (annualized) annualized GDP and .275. The capital intensity parameter is θ = .36. We set the Benchmark monetary policy at λ_1 = 1.2 and λ_2 = .3, so much of the weight is on the absorption deflator rather than exchange rates. Cook and Devereux (2004) show that this rule does a reasonable job capturing the response of domestic interest rates in a dynamic general equilibrium model of the East Asian crisis.

We set the dynamics of the model to most closely match the dynamic response which features a persistent and hump-shaped decline in production, consumption and investment. We assume that prices change on average every six quarters κ = .84. The consumption habit formation parameter is set at h = .5. The investment adjustment cost is set at Φ_K = .75. During the East Asian crisis, we observe indices for bond yields in Korea and Thailand constructed by HSBC. Country premiums over 3 month US Treasuries reach a peak of approximately 700 annualized basis points. Premiums on some long-term bonds rise by similar levels indicating a persistent shock. We calibrate the size of the shock equal to 1.7% (i.e. 7% annualized) with a persistence equal to ρ= .95.

IV Results

In this section, we describe the results of a `crisis' shock in the form of an increase in the external risk premium on the two emerging market economies. We wish to examine how closely our model can account for the actual macroeconomic experience of the East Asian crisis as described in Figure 1. We also examine the symmetric model under the assumption of local currency pricing (blue lines).

We can first describe the qualitative effects of a rise in the exogenous world risk premium. We discuss the impact on one economy, e.g. Korea. The effects on the other small economy are analogous. The rise in the world cost of borrowing leads to a fall in domestic investment and consumption. Consumption falls, due to both substitution and wealth effects, because the economy is a net debtor. The fall in domestic absorption will lead to a decline in domestic aggregate demand and in GDP. The behavior of imports and exports depends on the particular pricing assumptions made. First assume that export prices within the region are set in terms of *local currencies*. That is, export prices from Korea to Thailand are set in terms of Thai bath, and exports to the United States are set in dollars. In that case, the nominal price of exports facing US consumers does not change, and demand is unaffected. In the same way, Thai consumers see no effect on their import prices. But exports to Thailand will fall anyway, because of the fall in Thai absorption. On the other hand, there is immediate and full pass-through of the nominal depreciation into import prices of Korea. Thus, import prices rise, and imports fall. This generates a compensating rise in demand for domestic goods, but the overall effect is small, since imported goods and home produced goods are relatively poor substitutes according to the calibration.

If, on the other hand, all export prices within the region are set in US dollars, then the regional shock has a much greater impact on aggregate demand for Korea. The reason is that

Thailand's devaluation will lead to a fall in demand for Korean goods, as their price rises by just as much as the price of goods from the rest of the world. Korean exports to Thailand fall precipitously, and this cases a much bigger negative impact on Korean GDP.

Figure 5 describes the impulse response of the model to a persistent shock to the foreign risk premium, for the two types of pricing mechanisms. With local currency pricing, GDP, investment, consumption, and imports fall. Exports fall slightly on impact, as sales to the rest of the world are unchanged, but regional sales fall. After this, exports start to grow and US dollar prices fall over time, so that exports to the rest of the world increase. Imports immediately fall, as import prices rise. Qualitatively, Figure 5 resembles the main features of the response of our sample of economies to the East Asian crisis. But quantitatively, the overall effects are smaller than in the data. The fall in GDP is about half of the observed fall in the three worst hit East Asian economies (6 as opposed to 12 percent). This is mainly because consumption falls by less (6 percent as opposed to 16-18 percent in the data), but also exports fall by much less than they did in Malaysia and Thailand.

The crisis shock leads to an immediate large nominal depreciation of 30 percent in the model. This is smaller than the approximately 40 percent persistent depreciation that takes place in the data. In the data, the immediate impact of the crisis on exchange rates is also much higher – about 60 percent. But there is significant `overshooting' of exchange rates in all economies, and after a few months all the economies exchange rates converged to around a 40 percent depreciation.

Even in the case of local currency pricing, we find significant persistent in the real effects of the crisis shock. This is due partly to the persistence in the risk premium shock itself, but also to the elements of propagation built into the model, in particular adjustment costs of investment, habit persistence, and gradual nominal price adjustment.

Figure 5 also illustrates the effect of the crisis shock under the assumption of dollar currency pricing. In this case, the effects of the shock are much greater, and more persistent. This is due to the fact that depreciation of a trading partner's currency leads to a much larger drop in exports to the trading partner than takes place under local currency pricing. The depreciation causes a large rise in the domestic currency price of regional trading partners export goods. The result is a very powerful propagation effect of the shock, purely internal to the region, as Korean imports from Thailand fall sharply, and Korean exports to Thailand fall in the same manner.

Quantitatively, we find that the dollar currency pricing mechanism leads to a much closer correspondence between the model and the data, in most dimensions. The fall in GDP is much greater than with local currency pricing, as it now reflects the precipitous fall in intra-regional trade. GDP falls by about 11 percent in the model, very close to that in the data for Malaysia, Korea and Thailand. Moreover, the persistence of GDP is much greater than before. GDP does not return to trend until about 10 quarters. This matches quite well the persistence in the deviation of the crisis countries GDP from trend – we see from Figure 1 that the three crisis countries all return to trend in mid 2000.

The fall in consumption is also much greater than with local currency pricing, and closer to that in the data. Imports fall now by just under 30 percent – approximately the same as in the data. Exports fall by 10 percent – close to that seen in Malaysia and Thailand. Exports to the rest of the world are unchanged on impact, while exports to East Asia fall by 25 percent. This is larger than that experienced in Korea and Malaysia, but close to the fall in regional exports experienced by Thailand. Investment falls by about 50 percent – again almost the same as that experienced in Malaysia and Thailand. Finally, the nominal exchange rate depreciates by more under dollar currency pricing. The persistent nominal

depreciation of about 33 percent is greater than under local currency pricing, but less than that seen in the data.

Quantitatively, we therefore see that the dollar currency pricing assumption provides a fairly good description of the magnitude and persistence of the main macroeconomic effects of the Asian crisis. Given that this pricing assumption seems quite consistent with the observed data on trade prices and exchange rates, we suggest that it acted as a central element in the propagation mechanism of the crisis within the East Asian region.

Since our model provides a reasonable account of the East Asian crisis under a given monetary policy rule, an important question to ask is how would the crisis have played out under alternative policy rules. In particular, what would be the consequence of putting more weight on exchange rate stability in the monetary rule described above? Figure 6 shows how this would affect the outcome of the crisis. In the Figure, the red line describes the benchmark case of dollar currency pricing from Figure 5. The blue line shows the impact on the country that follows a monetary policy putting more weight on exchange rate stability, while the green line describes the effect on the country following the benchmark monetary policy rule. Under the exchange rate stabilization policy, we set $\lambda_1 = .75$ and $\lambda_2 = .75$, Clearly, a country that attempts to prevent exchange rate adjustment incurs large immediate costs. Since real interest rates must rise a lot more, absorption and GDP fall by considerably more for this country. In particular, GDP falls by about 70 percent more than in the benchmark case, and the recession is much more prolonged. The effect on the country that follows the benchmark policy is more involved. In the Figure, we see that this country experiences a slightly greater fall in GDP than it would if all countries followed the benchmark monetary policy rule. There are two effects at work. If all countries depreciate as in the benchmark model, there is a substantial fall in regional import demand due to dollar currency pricing, as described in Figure 5. On the other hand, if one country places more

weight on exchange rate stabilization, then its total absorption falls by a lot more, which reduces regional import demand in itself. In the baseline calibration, we find that the second effect tends to be slightly greater than the first effect, so the country following the benchmark monetary policy rule experiences a greater recession when the other country tends to stabilize the exchange rate. It is possible to show, however, that this ranking may be reversed. In particular, if there is a higher elasticity of substitution between East Asian goods, then in the benchmark monetary policy regime, the collapse in inter-regional trade will be much more. In this case, it is better, in the sense of a higher level of GDP, for the country following the benchmark rule for the other country to stabilize its exchange rate.

V. Conclusions

We have argued that the collapse in intra-regional trade is an important factor in the quantitative accounting for the East Asian crisis. Central to this is the role of the US dollar in pricing exports. In a sense, this represents another aspect of dollarization that may be important in crises, quite distinct from `liability dollarization' which has been a major part of the recent literature on understanding crises (e.g. Aghion et al, 2000, 2001).

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Figure 1a Korea

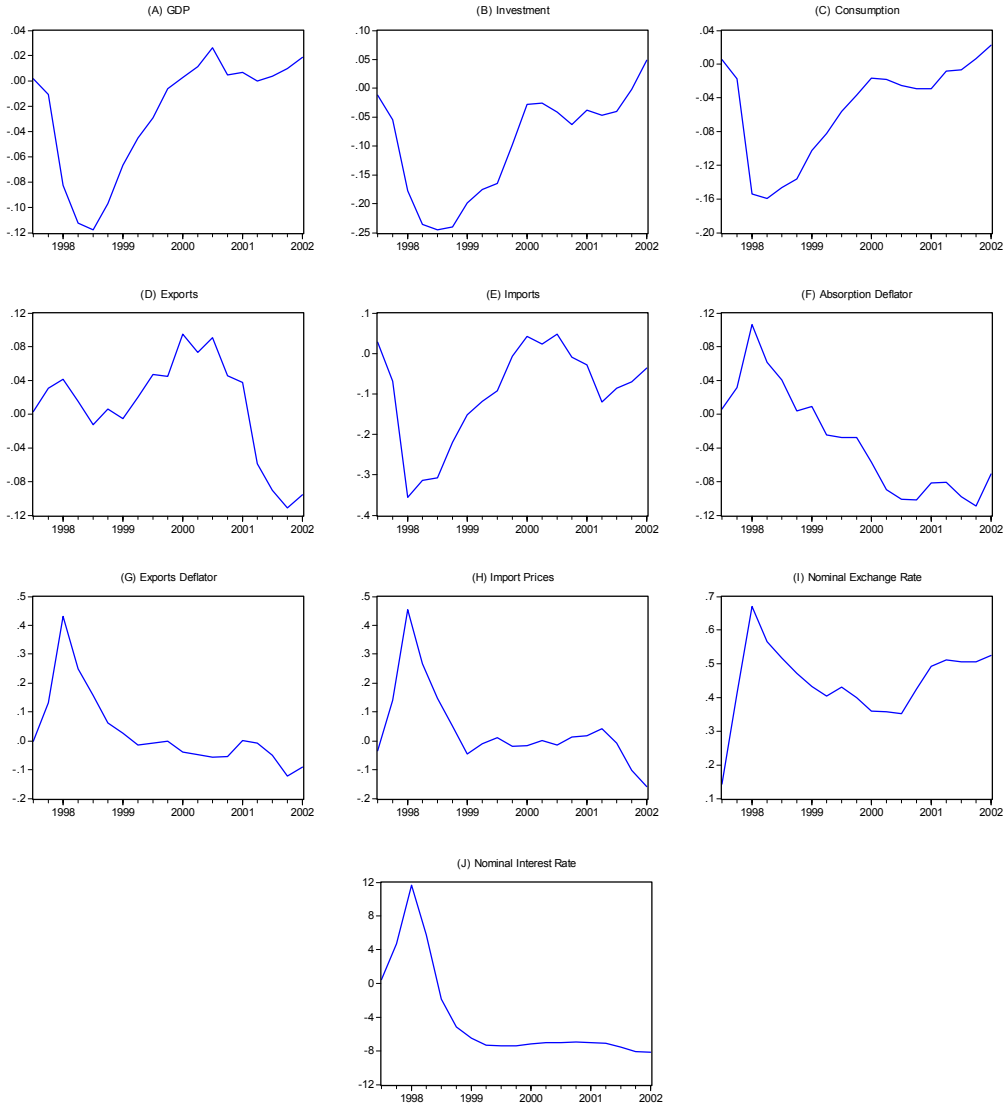


Figure 1b Malaysia

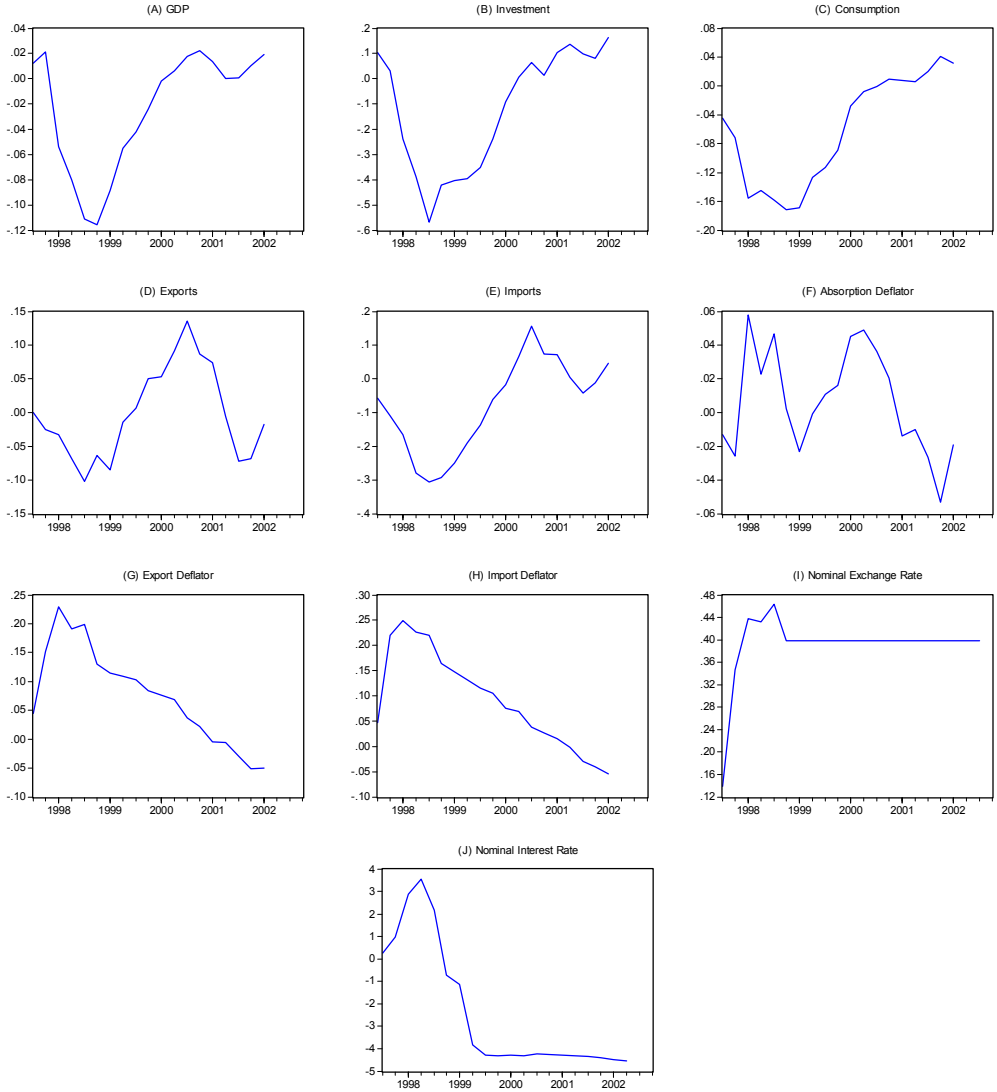


Figure 1c Thailand

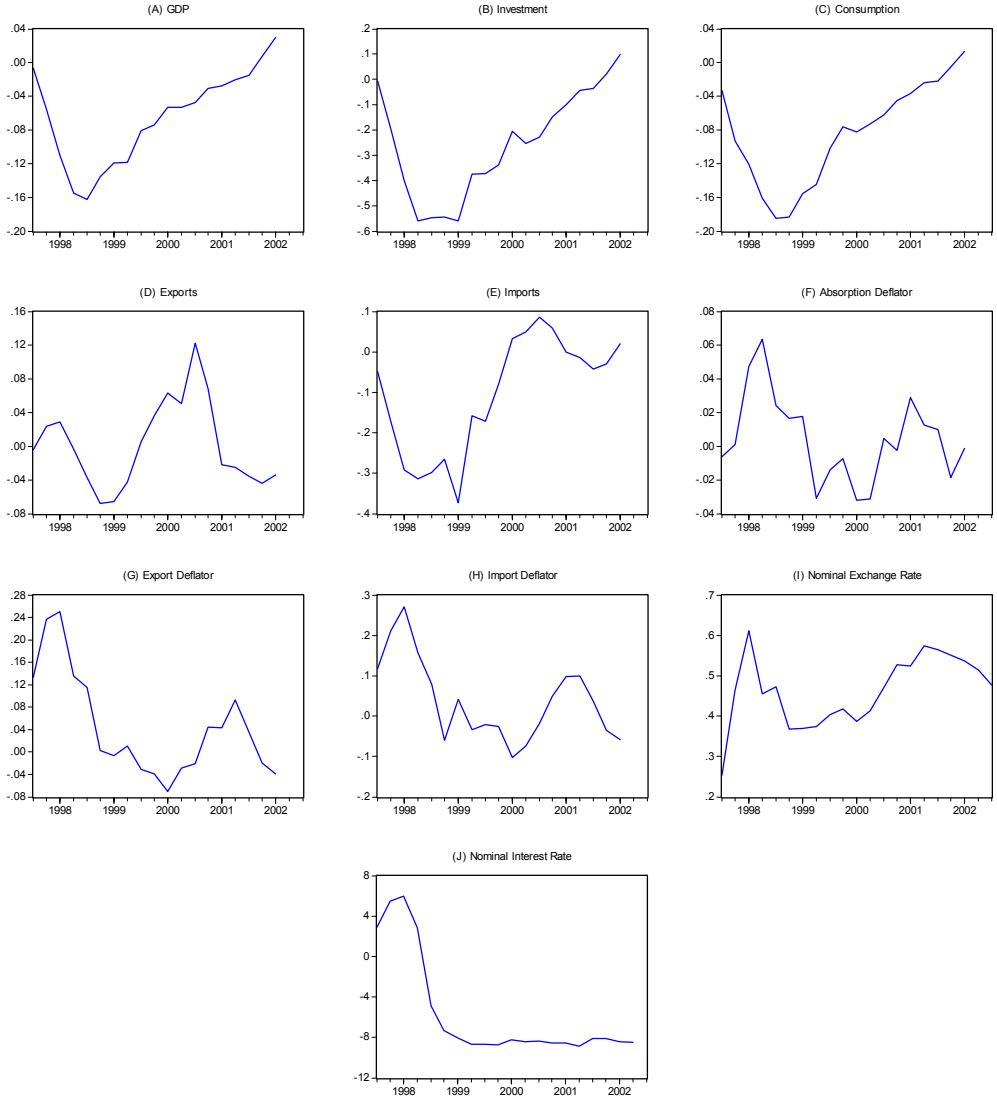


Figure 2 Real Exports by Region

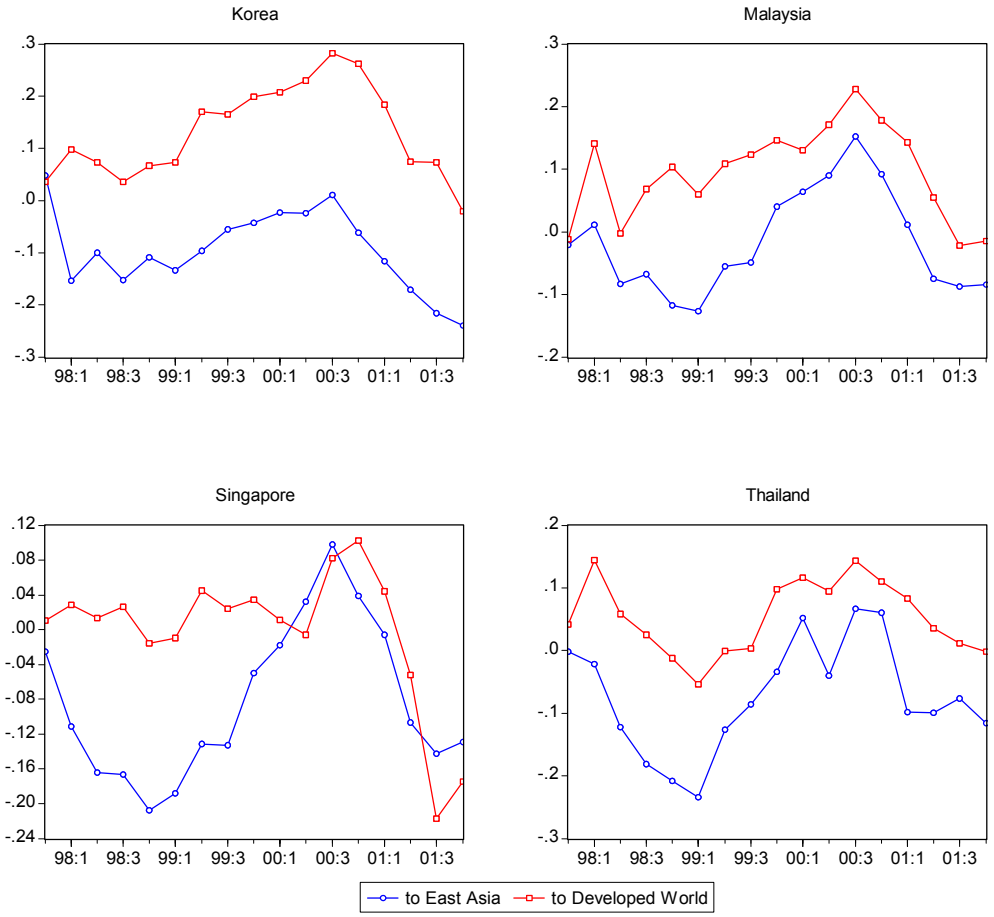


Table 1. Exports to Asia as a percentage of exports to Asia plus exports to Antipodes, NAFTA, EU, and Japan on a 2-year average basis.

	1986	1988	1990	1992	1994	1996	1998	2000	2002
Indonesia		74.76%	71.40%	67.03%	63.84%	61.76%	58.95%	59.37%	57.03%
Korea	14.21%	18.05%	24.25%	36.76%	41.53%	48.16%	42.52%	42.56%	48.22%
Malaysia	45.99%	44.74%	46.25%	46.07%	46.13%	48.62%	44.00%	45.99%	50.70%
Philippines	22.18%	19.62%	20.21%	18.57%	24.85%	26.40%	30.75%	34.16%	41.43%
Taiwan		19.68%	25.46%	32.71%	39.80%	43.79%	42.16%	42.58%	48.12%
Thailand	30.20%	26.75%	24.87%	28.93%	36.78%	39.39%	35.31%	37.82%	41.50%

Table 2

Thailand: Structure of Import Payments (Percent Share)

Currency

	1993	1994	1995	1996	1997	1998	1999	2000
US dollar	74.3	77.1	80.7	80.1	80.4	80.7	79.2	79.0
baht	0.6	0.7	0.5	0.8	1.7	1.7	2.2	2.4
Japanese yen	11.8	11.0	9.4	9.6	9.0	9.6	11.9	12.2
Deutsche mark	5.1	4.6	3.6	3.5	3.5	2.9	2.7	2.1
Pound sterling	1.5	0.9	0.9	1.1	0.8	0.6	0.4	0.4
Euro	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.9
Singapore dollar	1.4	1.4	1.1	1.0	1.0	0.8	0.8	0.8
Others	5.3	4.3	3.8	3.9	3.6	3.7	2.5	2.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Thailand: Structure of Export Receipts (Percent share)

Currencies

	1993	1994	1995	1996	1997	1998	1999	2000
US dollar	91.8	90.5	91.0	91.7	92.0	90.6	87.6	87.0
baht	0.9	1.6	2.4	1.3	2.1	2.6	3.7	3.9
Japanese yen	3.9	4.7	4.1	4.5	3.3	3.7	5.2	5.7
Deutsche mark	1.0	0.8	0.5	0.5	0.4	0.7	1.5	1.2
Pound sterling	0.8	0.6	0.3	0.4	0.3	0.4	0.3	0.2
Euro	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6
Singapore dollar	0.8	0.7	0.5	0.4	0.4	0.3	0.3	0.2
Others	0.8	1.1	1.2	1.2	1.5	1.7	1.2	1.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Korea: Export Receipts

Currencies

	1985	1990	1995	2000
US dollar	94.7	88	88.1	84.8
Japanese Yen	3.7	7.8	6.5	5.4
Deutsche Mark	0.6	2.1	2.4	1.8
Pound Sterling	0.3	0.5	0.8	0.7
Other	0.7	1.7	2.2	7.3

Korea: Import Payments

Currencies

	1985	1990	1995	2000
US dollar	82.4	79.1	79.4	80.4
Japanese Yen	12.3	12.7	12.7	12.4
Deutsche Mark	2	4.1	3.8	1.9
Pound Sterling	0.5	0.9	0.7	0.8
Other	2.8	3.4	3.4	4.4

Source: Bank of Thailand, McKinnon and Schnabl (2003)

TABLE 3	4 Month Export Price Change	
	Dec97-Mar98 from Sept97-Nov98	
	Won	dollar
Agricultural Products	0.219329	-0.09714
Marine Products	0.365858	-0.10156
Processed Marine Products	0.392361	-0.13416
Other Processed Beverages and Foods	0.464698	-0.05882
Processed Yarns & Threads	0.438428	-0.05825
Textile Fabrics	0.378759	-0.0181
Other Textile Products	0.484643	-0.01646
Textile Apparel	0.511259	-0.00475
Leather Clothes	0.5259	0
Apparel Accessory	0.511725	-0.01435
Leather Products	0.456833	-0.01928
Footwear	0.387143	-0.0403
Paper & Paper Products	0.271747	-0.2493
Refined Crude Petroleum Products	0.253213	-0.2555
Elementary Chemical Products	0.348456	-0.1736
Synthetic Rubber & Plastic Materials	0.43403	-0.09153
Other Chemical Products	0.498303	-0.02728
Rubber Products	0.502143	-0.02356
Plastic Products	0.454021	-0.07141
Nonmetallic Mineral Products	0.417459	-0.10476
Steel Rolling Mill Products	0.467854	-0.04176
Galvanized Sheets	0.467062	-0.05121
Other Basic Iron & Steel Products	0.443725	-0.05837
Basic Nonferrous Metal Products	0.425983	-0.09965
Hand Tools & General Hardware	0.461124	-0.06503
Screws & Wire Products	0.45761	-0.02713
Other Metal Products	-0.0215	0
General Purpose Machinery	0.461505	-0.07055
Special Purpose Machinery	0.405105	-0.04634
Electric Apparatus For Household	0.502062	-0.02343
Office, Accounting and Computing Machine	0.458809	-0.06646
Electrical Machinery & Apparatus	0.446042	-0.07811
Semiconductor Devices	0.230092	-0.29727
Other Electronic Tube & Electronic Compo	0.466548	-0.05891
Communication Equipment Apparatus	0.512333	-0.01349
Sound & Image Equipment Apparatus	0.501951	-0.01096
Precision Instruments	0.400556	-0.03385
Transportation Equipment	0.476563	-0.04757
Other Manufacturing Industry Products	0.516246	-0.00981

Table 4: Trade Prices and Exchange Rates

Korea: Monthly Changes 1990/01-2003/12

Dependent Variable	Export Price	Import Price
US dollar	0.69*** (10.99)	0.44*** (6.57)
Jap Yen	0.17*** (3.72)	0.28*** (5.73)
Euro[1]	-0.03 (-0.35)	-.03 (-0.34)
UK Pound	0.01 (0.01)	0.03 (0.3)
R2	0.8	0.72

Thailand: Monthly Changes 1996/01-2001/08

Dependent Variable	Export Price	Import Price
US dollar	0.76*** (9.45)	0.72*** (9.1)
Jap Yen	0.02 (0.34)	0.13* (1.9)
Euro[1]	0.12 (1.56)	0.07 (0.88)
UK Pound	0.0 (0.17)	-0.05 (-1.08)
R2	0.9	0.9

[1] D-mark substituted for euro before 1997. *** Significant at 1% level * Significant at 10% level

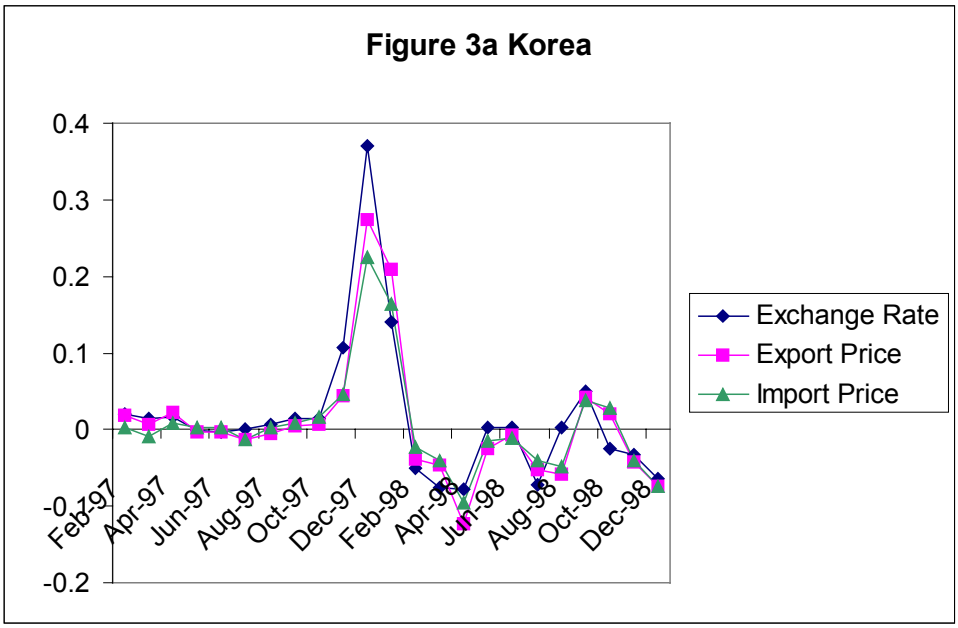


Figure 3a Korea
0.4
0.3
0.2
0.1
0
-0.2
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Jun-98
Aug-98
Oct-98
Dec-98
Exchange Rate
Export Price
Import Price

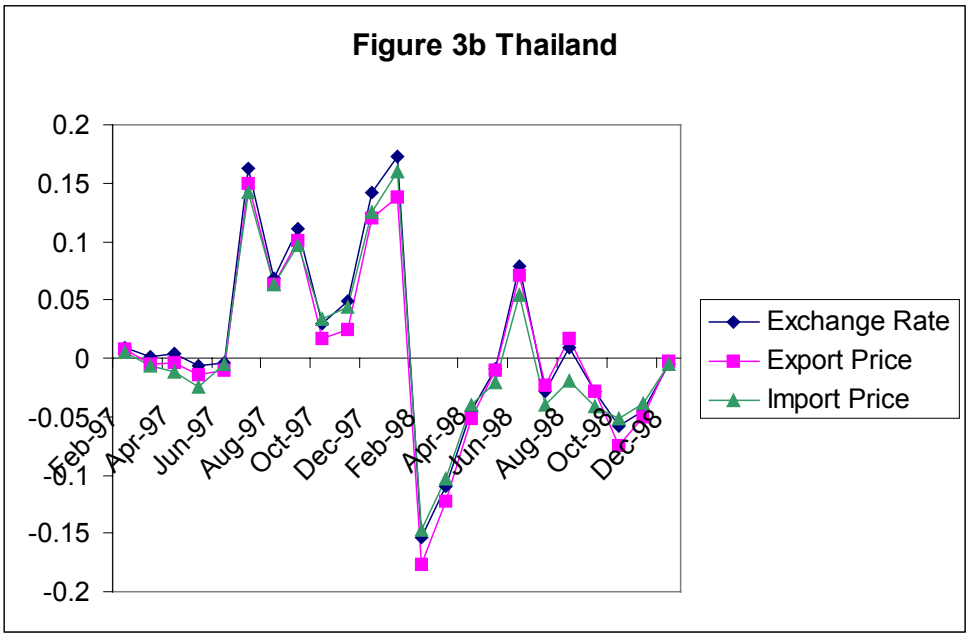


Figure 3b Thailand
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Jun-98
Aug-98
Oct-98
Dec-98
Exchange Rate
Export Price
Import Price

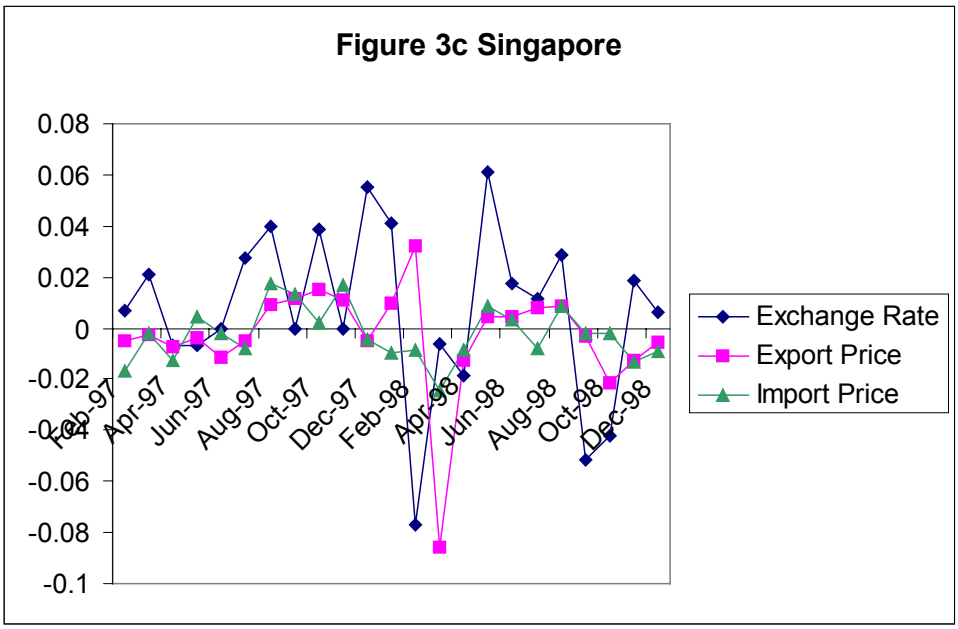


Figure 3c Singapore
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Jun-98
Aug-98
Oct-98
Dec-98
Exchange Rate
Export Price
Import Price

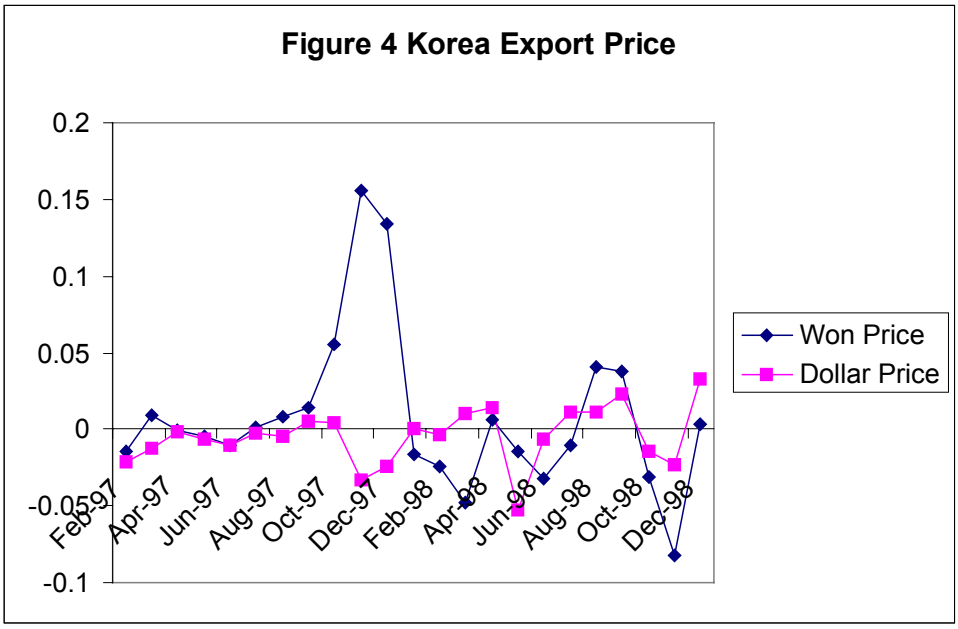
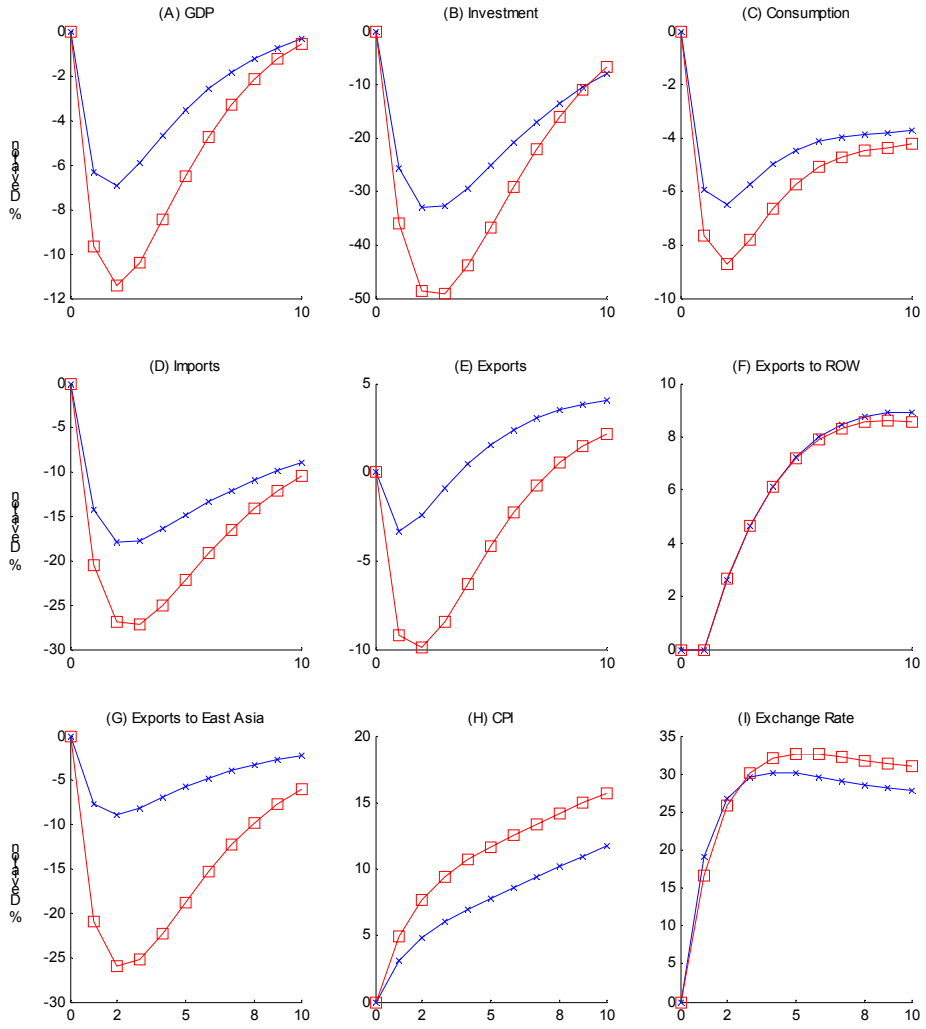


Figure 4 Korea Export Price
0.2
0.15
0.1
0.05
0
-0.05
-0.1
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Jun-98
Aug-98
Oct-98
Dec-98
Won Price
Dollar Price

Figure 5 LCP versus Dollar Currency Pricing



■ Dollar Currency Pricing
x Local Currency Pricing

Figure 6: Targeting the Exchange Rate