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ABSTRACT

External Currency Pricing and the East Asian Crisis*

This Paper provides a quantitative investigation of the East Asian crisis of 1997-99. There are two essential features of the crisis that we focus on. These 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 multi-country macroeconomic 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. Without the regional dimension and dollar pricing of exports, the model fails to account for the depth and severity of the crisis.

JEL Classification: F40
Keywords: East Asian crisis, exchange rate and small open economy

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I. Introduction

Exports have played a central role in the rapid industrialization of the economies of East Asia. The unprecedented growth in the region has coincided with the development of a regional trading bloc. In the early 1980's, the great majority of exports from the newly industrializing economies of East Asia went to OECD countries. Twenty five years later, exports to other East Asian (excluding Japan) countries were almost as large as exports to developed economies outside the region. A distinct facet of the East Asian trading bloc is that intra-regional trade has been denominated in currencies which are external to the region, principally the US dollar. While considerable attention has been paid to the macroeconomic implication of the foreign currency denomination of external debt in East Asia, much less attention has focused on this aspect of trade pricing. In this paper, we examine some of the implications of external currency denomination of intra-regional trade during a financial crisis.

Our paper attempts to provide an account of the East Asian crisis of 1997-1999 within the framework of a theoretical general equilibrium model. One of the puzzling theoretical problems in understanding the crisis is to explain why very large real exchange rate devaluations failed to generate an expansionary export boom. Despite real depreciations of 60 percent or more, export volumes either stagnated or actually fell for a year or more in most of the worst hit crises countries, including Korea, Malaysia, and Thailand.

The paper develops a quantitative dynamic general equilibrium model of the East Asian crisis. A key aspect of our modeling strategy is to view the crisis as not simply a capital market shock that hits a single small, open economy in isolation, but as a generalized aggregate shock to a region in which countries are interlinked through trade flows. Thus, the East Asian crisis is seen as a combination of a large external shock, and a powerful propagation mechanism, internal to the region. We are interested in two empirical questions. First, can the decline in intra-regional trade that occurred during the Asian crisis explain the decline in aggregate exports from crisis countries? Second, to what extent can the persistent decline in production in these economies can be traced to the decline in regional trade? Thus, we ask whether the regional propagation mechanism can explain the absence of the post-crisis export booms, and more generally, whether the persistence and severity of the crisis itself can be tied to the interdependence of the East Asian trading region.

Our quantitative approach to modeling the crisis is similar to a number of previous papers[1] – we make use of a sticky price open economy macroeconomic framework. But we differ from previous literature in two dimensions. First, we model the crisis within a multi-country framework. Second, 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*. We refer to this aspect of East Asian export pricing as `Dollar Currency Pricing'. We use detailed price data from East Asian countries to 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.

What difference does this pricing assumption make? We show that dollar currency pricing goes a long way in explaining the observed behavior of net exports in the East Asian crisis, and in particular helps to understand the lack of an immediate devaluation-fueled export boom. In our model, a devaluation of a country does not 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

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

import demand for a given country within the East Asian region just as much as it affects the neighbor's demand for exports from countries in the rest of the world, *even if the country within the region has itself devalued*. That is, a devaluation of a country does not immediately 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 regional partner's price of the country's exports.

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. With local currency pricing of exports, the model is able to reproduce many of the main *qualitative* features of the East Asian crisis. Quantitatively however, it fails to explain the depth and severity of the crisis, and it is highly inaccurate in modeling the post-crisis behavior of exports. But with dollar currency pricing, the model does quite well in providing both a qualitative *and* quantitative account of the crisis. The effect of dollar currency pricing is to lead to a precipitous drop in trade within the East Asia region, which helps us to quantitatively account for the observed export series, as well as the scale and persistence of the shock to output.

Our paper is related to a large literature on the causes of emerging market crises of the mid- to late-1990s. Chang and Velasco (2000, 2001) develop a model of self-fulfilling financial panics caused by a maturity mismatch in the domestic banking sector as the source of the crisis. In the model of Burnside, Eichenbaum and Rebelo (2001a), a currency mismatch occurs within the banking system, due to government loan guarantees. Dooley (2000) also argues that implicit loan guarantees of private-sector debt in East Asia generates the possibility of a currency crisis if those guarantees were called and the resulting debts were to be monetized. Burnside, Eichenbaum and Rebelo (2001b) construct a model that allows for a quantitative study of the size of debts that might be incurred and the resulting effect on exchange rates. In addition, many papers have stressed the aggregate importance of balance-sheet aspects of the East Asian crisis; many private East Asian debtors faced a mismatch in the currency denomination of their assets and liabilities. Aghion, Bachetta, and Bannerjee (2000, 2001) show how balance-sheet constraints may lead to a self-fulfilling exchange rate crisis. Cespedes, Chang and Velasco (2004), Cook (2004), and Choi and Cook (2004) adapt the financial accelerator model of Bernanke, Gertler and Gilchrist (1999) to explore the effects of external financing risk premia and currency mismatches in the operation of monetary policy in emerging markets[2]. Arellano and Mendoza (2002) show that balance-sheet constraints may be important in generating 'sudden stops,' defined as a switch towards a binding national constraint on capital inflows for a borrowing country (see Calvo and Reinhart, 1999).

While most of these papers explore the underlying causes of the crisis, whether from errors in policy-making, or fragility in international capital markets, we avoid taking a stand on this by modeling the crisis as an exogenous shock to country risk spreads on U.S. dollar bonds. In principle this movement in spreads could be driven by herding effects in international markets (see Calvo and Mendoza, 2000) or by an elimination of loan guarantees by domestic authorities (see Corsetti, Pesenti, and Roubini, 1999). We calibrate the shock to the movement in observed risk spreads, and ask how well the response to the crisis can be tracked by our multi-country macro model.

Some other papers have studied the quantitative aspects of financial crises. Mendoza (2001) studies the effects of sudden stops in a quantitative business cycle model. McKibbin (1998) studies the effect of an interest rate shock on a multi-country model. Neumayer and Perri (2004) examine the business cycle behavior of emerging markets faced with country risk premium shocks calibrated to the behavior of Argentine spreads. Burstein, Eichenbaum

[2] Balance sheet constraints (related to trade credit) may represent another possible explanation for the lack of an devaluation related export boom. In order to highlight our mechanism, we abstract away from all such

and Rebelo (2002) quantitatively examine the effect of interest rate shocks on exchange rates and nominal prices. Gertler, Gilchrist and Natalucci (2003) explore whether balance sheet effects help in explaining the contraction that occurred following the East Asian currency crisis. Our paper differs from these papers principally in the emphasis on the regional interaction perspective, as well as the importance of external currency pricing in exports.

The rest of the paper is organized as follows. Section II first discusses the importance of US dollar pricing of East Asian export goods, and then describes the effects of the East Asian crisis on the main macroeconomic aggregates, trade and exchange rates for Korea, Malaysia, and Thailand. Section III describes a three country, open economy model. Section IV discusses the calibration of the model. Section V presents the results, and section VI offers some conclusions.

II. Export Pricing and the East Asian Crisis

A. Pricing in the East Asian Trade Block

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 the EU, North America, and Japan, where in addition to our three sample 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 suggest that it may be important to allow for regional trade effects when accounting for the East Asia crisis.

The observed behavior of export and import prices is of key importance in the workings of our theoretical model. The model assumes that both export and import good prices for each emerging economy are quasi-fixed in US dollars. We refer to this as `Dollar

constraints in our paper.

Currency Pricing'. As an initial piece of evidence, Figure 1 shows the changes in import and export prices at the monthly frequency, from February 1997 to the end of 1998, for Korea and Thailand[3]. 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 1 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.

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[4]. Indirect evidence on the role of the US dollar as an export currency can also be obtained from 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, Australian imports in 1997 were denominated overwhelmingly in US dollars,

[3] We have not been able to obtain monthly trade prices for Malaysia.

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 more support for the assumption of dollar currency pricing may be gleaned from a detailed study of Korean export and import pricing. Table 3 further breaks down the price adjustment of Korean exports by individual categories of goods, and reports export prices both on a dollar basis as well as a Won basis. 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. Figure 2 illustrates a similar phenomenon for Korean *aggregate* export prices. Aggregate 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.

[4] More detailed evidence for Thailand indicates that substantial Baht export invoicing is used only for smaller ASEAN countries, in particular Laos, Cambodia, and Myanmar.

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[5]. 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 a 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 implied `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.

B. Anatomy of the 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.

We define the "Asian crisis" as the difference between actual outcomes and the conditional expectation of the variable at the end of the second quarter of 1997. Figure 3 shows the impact of this identified shock for a number of variables (all data is from the CEIC database). We first examine the impact on some aggregate quantity series drawn from the national income accounts. The variables are seasonally adjusted GDP, investment, consumption, imports and exports. Investment is defined as gross capital formation while

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

consumption is personal or household consumption expenditure. Korean data is adjusted by the statistical authorities, while we adjust Malaysian and Thai data using the X-12 filter. We estimate a 2nd order AR with log linear and quadratic trends using quarterly data from 1980, or the beginning of quarterly accounts data (1991, in the case of Malaysia and, 1993, in the case of Thailand) through the first quarter of 2004. Forecasts of the post June, 1997 path of the variables are constructed using the estimated AR process with trend. Figure 3, Panel A-E illustrates the *difference* between the historical sample and these forecasts.

Though some details vary, we see a similar pattern for each of the three countries. In each country, there is a persistent, hump-shaped contraction in GDP with a peak decline between 8-12%. After 10 quarters, the path of GDP has approximately returned to the trend-growth path. Investment and consumption also decline for 10 quarters in a similarly humped-shaped path. At the trough, investment declines by approximately 50% relative to the pre-crisis forecast, while the trough of consumption ranges from 12 to 15% below the pre-crisis forecast.

The fact that GDP falls by much less than absorption 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 to approximately 8% below the pre-crisis forecast in Malaysia and Thailand, and remained essentially unchanged in Korea. About a year and a half after the crisis, an export boom starts up in all countries, and exports are substantially above trend in late 1999.

Each of the countries collects monthly data on exports by country of destination, at least from 1988. For each quarter, we measure the exports of that go to Asian economies (excepting those countries of the former Soviet Union and the Middle East). We add the exports that go to the Australia, New Zealand, EU, NAFTA and Japan, and define these as exports to the developed world. Korean data (which are recorded in US dollar values) are converted to won using the average spot won-dollar rate. We convert these values into constant dollars using export deflators from the national income accounts. In the case of Malaysia, quarterly export deflators prior to 1991 are estimated using annual growth rates in the export deflator. In the case of Thailand, we use a monthly export price index to estimate quarterly inflation in the export deflator before 1993. We define the sum of the two series (exports to Asia and exports to the Developed world) as total exports. Each export series is seasonally adjusted with the X-12 filter. For each series, we estimate a 4th order auto-regression with a linear-quadratic term. In each case, we identify the Asian crisis as the difference between the June, 1997 conditional forecast and the actual realization during the crisis.

Why do exports remain so depressed following a substantial real devaluation? Exports to the East Asia region fall sharply and persistently, reaching a trough around 12% below trend in Korea and Malaysia and slightly more than 20% in Thailand. This 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. By contrast, exports to the developed world rises above trend, albeit slowly.

Using the national income accounts, we also construct a measure of the absorption deflator (the ratio of constant dollar to current dollar absorption). Figure 3 H shows the response of this nominal price index to the shock. In each country, we see a relatively small rise in the price level, followed by a reversion to trend. This is interesting given the response of the nominal exchange rate to the crisis. We measure the response of the spot US dollar exchange rate to the crisis as the difference between the log of the actual realization of the exchange rate and the mean log exchange rate in the first half of 1997. We observe, in Figure 3 I, sharp nominal depreciations in either the 3rd or 4th quarter of 1997, reaching extremes of 50-60% below the pre-crisis value. Over the course of 1998, all of the currencies strengthen before reaching a level between 25 to 40% below the pre-crisis level.

We now go on to construct a quantitative dynamic general equilibrium model that can account for some of these crisis characteristics.

III. 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. The currency of the developed world is 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 to 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 an East Asian composite exports good:

$$X_t^{D,EA} = s_{D,EA}\left(\frac{P_t^{EA,D}}{P_t^D}\right)^{-\phi} A_t^D \qquad (1.1)$$

where A_t^D is total absorption of the developed world, $P_{t,}^{EA,D}$ represents the dollar price of East Asian exports to the developed world, the parameter ϕ is the elasticity of demand for East Asian exports in general and finally, $s_{D,EA}$ represents a share parameter. The composite demand for East Asian goods is itself a CES function of goods from Korea and Thailand (denoted KR, and TH, respectively):

$$X_t^{D,EA} = \left[\tfrac{1}{2}^{\frac{1}{\gamma}} \left\{X_t^{D,KR}\right\}^{1-\frac{1}{\gamma}} + \tfrac{1}{2}^{\frac{1}{\gamma}} \left\{X_t^{j,TH}\right\}^{1-\frac{1}{\gamma}} \right]^{\frac{1}{1-\frac{1}{\gamma}}} \qquad (1.2)$$

where

$$X_t^{D,j} = \tfrac{1}{2}\left(\frac{P_{t,\$}^j}{P_t^{EA,D}}\right)^{-\gamma} X_t^{D,EA}. \qquad (1.3)$$

Here, $X_t^{D,j}$ is the exports of country j to the developed world, $P_{t,\$}^j$ is the dollar price of the exports of country j. The price index for $P_{t,}^{EA,D}$ is:

$$P_t^{EA,D} = \left(\tfrac{1}{2}\left(P_{t,\$}^{KR}\right)^{1-\gamma} + \tfrac{1}{2}\left(P_{t,\$}^{TH}\right)^{1-\gamma}\right)^{\frac{1}{1-\gamma}} \qquad (1.4)$$

the parameter γ is the elasticity of demand for each individual East Asian country good.

International financial markets provide funds to each country at an exogenous interest rate, $1+r_t^{EA,j}$. Interest rates are a function of the world interest rate, r_t, an exogenous regional premium, rp_t, and an endogenous country risk premium which is a function of the deviation of net foreign debt D_j^t from an exogenous steady state level $\bar{D}^j$.

$$1+r_t^{EA,j} = (1+r_t)\cdot(1+rp_t)\cdot\left(D_t^j / \bar{D}^j\right)^{\upsilon} \qquad (1.5)$$

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 the dollar interest rate $1+r_t^{EA,j}$, 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:

$$\begin{aligned} &S_t^j D_t^j + B_t^j \\ &= (1+r_{t-1}^{EA})S_t^j D_{t-1}^j + (1+i_{t-1}^j)B_{t-1}^j + P_t^j\left[C_t^j + I_t^j + G_t^j\right] - \left(W_t^j H_t^j + R_t^j K_t^j + \Pi_t^j\right) \end{aligned} \tag{1.6}$$

Capital accumulation is determined by the condition:

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

where the household faces adjustment costs of changing capital that depend on the rate of change of investment. We follow Christiano et al. (2003) in using this alternative model of investment adjustment costs in order to allow the investment response to the crisis to be more persistent.

The infinitely lived households maximize discounted utility, defined by:

$$E_t U_t = E_t \sum_{j=t}^{\infty} \beta^t \cdot \left\{ \ln(C_t^j - hC_{t-1}^j) - \Gamma H_t^j \right\} \tag{1.7}$$

Households display `habit persistence' with respect to consumption. Again, this specification is introduced so as to allow for greater persistence in the response of aggregate consumption to the crisis.

C. 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):

$$C_t^j + I_t^j + G_t^j = X_t^j = \left[a^{\frac{1}{\phi}} \left\{ X_t^{j,EA} \right\}^{1-\frac{1}{\phi}} + (1-a)^{\frac{1}{\phi}} \left\{ IM_t^{j,D} \right\}^{1-\frac{1}{\phi}} \right]^{\frac{1}{1-\frac{1}{\phi}}} \quad (1.8)$$

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

$$\begin{aligned} X_t^{KR,EA} &= \left[b^{\frac{1}{\gamma}} \left\{ X_t^{KR,KR} \right\}^{1-\frac{1}{\gamma}} + (1-b)^{\frac{1}{\gamma}} \left\{ X_t^{KR,TH} \right\}^{1-\frac{1}{\gamma}} \right]^{\frac{1}{1-\frac{1}{\gamma}}} \\ X_t^{TH,EA} &= \left[b^{\frac{1}{\gamma}} \left\{ X_t^{TH,TH} \right\}^{1-\frac{1}{\gamma}} + (1-b)^{\frac{1}{\gamma}} \left\{ X_t^{TH,KR} \right\}^{1-\frac{1}{\gamma}} \right]^{\frac{1}{1-\frac{1}{\gamma}}} \end{aligned} . \quad (1.9)$$

D. Production

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

$$Y_t^j = \left\{ K_t^j \right\}^{\theta} \left\{ H_t^j \right\}^{1-\theta} \quad (1.10)$$

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

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

E. 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:

$$X_t^{l,j} = \left[\int_0^1 \left\{ x_{t,i}^{l,j} \right\}^{1-\frac{1}{\xi}} di \right]^{\frac{1}{1-\frac{1}{\xi}}} \qquad P_t^{l,j} = \left[\int_0^1 \left\{ p_{t,i}^{l,j} \right\}^{1-\xi} di \right]^{\frac{1}{1-\xi}} \qquad \frac{x_{t,i}^{l,j}}{X_t^{l,j}} = \left(\frac{p_{t,i}^{l,j}}{P_t^{l,j}} \right)^{-\xi} \tag{1.11}$$

In the case of domestic demand ($l = j$), retailer i buys materials at the competitive price MC_t^j. Retailers also face direct costs of price change however. Following Bergin and Tchakarov (2004), we model these costs as resources used up in the process of adjusting prices. If retailer i changes its price, then it suffers a resource loss of $\tilde{\Delta}_{t,i}^{l,c} = \frac{\kappa}{2} \left(\frac{p_{t,i}^{l,j} - p_{t-1,i}^{l,j}}{p_{t-1,i}^{l,j}} \right)^2$ per unit of output. Hence, if the retailer purchases $x_{t,i}^{l,j}$ from competitive suppliers, and changes its price at time t, then its effective revenue (in the currency of sale) net of costs of price change will be:

$$p_{t,i}^{l,j} x_{t,i}^{l,j} (1 - \tilde{\Delta}_{t,i}^{l,j}) = p_{t,i}^{l,j} x_{t,i}^{l,j} - \frac{\kappa}{2} \frac{\left(p_{t,i}^{l,j} - p_{t-1,i}^{l,j} \right)^2}{p_{t-1,i}^{l,j}} x_{t,i}^{l,j} \equiv p_{t,i}^{l,j} x_{t,i}^{l,j} - \Delta_{t,i}^{l,j} x_{t,i}^{l,j}$$

where $\Delta_{t,i}^{l,j}$ is implicitly defined. Hence, in each period, retailers have profits equal to:

$$\Pi_{t,i}^{l.j} = \left[p_{t,i}^{l,j} - MC_t^j - \Delta_{t,i}^{l.j} \right] \cdot x_{t,i}^{l.j} \tag{1.12}$$

We assume that retailers must set the price for period t before the beginning of the period (as in Rotemberg and Woodford, 1997) to maximize expected profits, so that retailers face the problem:

$$\begin{aligned} &\max_p E_{t-1} \left[\sum_{m=t}^{\infty} \left(\prod_{n=t}^{m} \tfrac{1}{(1+i_n)} \right) \Pi_{m,i}^{l,j} \right] \\ &= \max_p E_{t-1} \left[\sum_{m=t}^{\infty} \left(\prod_{n=t}^{m} \tfrac{1}{(1+i_n)} \right) \{ p_{m,i}^{l,j\,1-\xi} - MC_t^j p_{m,i}^{l,j\,-\xi} - \frac{\kappa}{2} \frac{\left(p_{m,i}^{l.j} - p_{m-1,i}^{l.j} \right)^2}{p_{m-1,i}^{l.j}} p_{m,i}^{l,j\,-\xi} \} \cdot X_m^j \cdot P_m^{j\xi} \right] \end{aligned} \tag{1.13}$$

We derive the first order conditions for expected profit maximization, and then impose symmetry so that the price for all *i* firms is identical. The optimal price for sale in the domestic market (when *l=j*) follows the dynamics:

(1.14)

$$1-\xi = E_{t-1}[-\xi \frac{MC_t^j + \Delta_t^{j,j}}{P_t^{j,j}} - \kappa \frac{\left(P_{t,i}^{j,j} - P_{t-1,i}^{j,j}\right)}{P_{t-1,i}^{j,j}} + \frac{\beta}{(1+i_t)}\left(\frac{X_{t+1}^{j,j}}{X_t^{j,j}}\right)\cdot\left\{\kappa \frac{\left(P_{t+1}^{j,j} - P_t^{j,j}\right)}{P_t^{j,j}} + \kappa \frac{\Delta_{t+1}^{j,j}}{P_t^{j,j}}\right\}]$$

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

$$\widetilde{\Pi}_{t,i}^{l,j} \equiv S_t^j \cdot \left(p_{t,i}^{l,j} - {MC_t^j}/{S_t^j} - \Delta_{t,i}^{l.j} \right)\cdot x_{t,i}^{l,j} \qquad \Delta_{t,i}^{l.j} = \frac{\kappa}{2}\frac{\left(p_{t,i}^{l.j} - p_{t-1,i}^{l.j}\right)^2}{p_{t-1,i}^{l.j}}.$$

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

$$\max_p E_{t-1}\left[\sum_{m=t}^{\infty}\left(\prod_{n=t}^{m}\tfrac{\kappa}{(1+i_n)}\right) S_m^j \left\{P_m^{l,j}\right\}^{\xi} X_m^{l,j}\left\{\left\{p_{t,i}^{l,j}\right\}^{1-\xi} - \left\{p_{t,i}^{l,j}\right\}^{-\xi} {MC_m^j}/{S_m^j} - \Delta_{t,i}^{l.j}\left\{p_{t,i}^{l,j}\right\}^{-\xi}\right\}\right] \quad (1.15)$$

Again imposing symmetry, the first order condition for this problem is given by:

$$1-\xi = E_{t-1}[-\xi \frac{{MC_t^j}/{S_t^j} + \Delta_t^{l.j}}{P_t^{j.l}} - \kappa \frac{\left(P_{t-1}^{l,j} - P_{t-1}^{l,j}\right)}{P_{t-1}^{l,j}} + \frac{\beta}{(1+i_t)}\cdot\left(\frac{S_{t+1}^j}{S_t^j}\right)\left(\frac{X_{t+1}^{l,j}}{X_t^{l,j}}\right)\cdot\left\{\kappa \frac{\left(P_{t+1}^{l,j} - P_t^{l,j}\right)}{P_t^{l,j}} + \kappa \frac{\Delta_{t+1}^{l.j}}{P_t^{l,j}}\right\}]$$

(1.16)

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

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

while the East Asian price index for each country defined as:

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

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

F. Interest Rates

The regional risk premium is assumed to follows an exogenous AR(1) process:

$$rp_t = \rho \cdot rp_{t-1} + \varepsilon_t \qquad (1.17)$$

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

$$1 + i_t = (1+i)\left\{ \frac{P_t^j}{P_{t-1}^j} \right\}^{\lambda_p} \left\{ \frac{S_t}{S_{t-1}} \right\}^{\lambda_s} \qquad (1.18)$$

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 nominal interest rates rose sharply in the post-crisis period, undoubtedly 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.

G. 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: $C^j(\Xi_t)$, $I^j(\Xi_t)$,), $X(\Xi_t)$, $X^T(\Xi_t)$, $X^N(\Xi_t)$, $X^{Td}(\Xi_t)$, $EX(\Xi_t)$, $IM(\Xi_t)$, $Y^T(\Xi_t)$, $Y^N(\Xi_t)$, $M(\Xi_t)$, $H(\Xi_t)$, $H^T(\Xi_t)$, $H^N(\Xi_t)$, $D(\Xi_t)$, $K^T(\Xi_t)$, $K^N(\Xi_t)$, $w^T(\Xi_t)$,, $p^T(\Xi_t)$,, $p^{\$T}(\Xi_t)$; 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.

$$\int_0^1 x_{t,i}^{ROW,j} di + \int_0^1 x_{t,i}^{j,j} di + \int_0^1 x_{t,i}^{l\neq j,j} di = Y_t^j \qquad j = TH, KR \qquad (1.19)$$

IV. Calibration and Solution

In the absence of a closed form solution, the model must be solved numerically. Since the Asian crisis represented a very large macroeconomic event by any metric, it seems inappropriate to rely on the usual log-linear approximation methods for characterizing the response to the crisis. Moreover, our interest is not in characterizing the average characteristics of these economies, but rather the response to the single large crisis event. In light of this, we solve a non-linear perfect foresight version of the model where there is a single persistent shock to the world interest rate at the beginning of the crisis. We use the Dynare software from CEPREMAP which implements the Newton method described in Juillard (1996). Our assumption is that the model will converge back to steady state in less than 1000 periods. Given this, numerically exact perfect foresight solutions for the effects of the crisis may be computed.

The complete calibration of the model is described in Table 5. We assume that the two small open economies are symmetric. To calibrate the steady-state great ratios, we use an averaging of the empirical counterparts for Korea and Thailand reported in Cook and Devereux (2004). The share of government in GDP is set at .106. The capital share parameter is set as $\theta = .301$. The share parameter of East Asian exports, $s_{D,EA}$, is set so that total exports as a share of in GDP $\frac{X^{j,D} + X^{j,j}}{GDP^j}$ is .301, for each country, when the relative price of East Asian goods to developed goods is 1. This corresponds to the average share for Korea and Thailand. The debt-sensitivity parameter, $\bar{D}^j$ is set so that steady-state external debt to annualized GDP is .275, again an average for the two countries. The share parameter, a, is set so that steady state imports are consistent with a real exchange rate equal to 1, which is the steady state real exchange rate that we use to drive export and debt share. In addition, we set the share parameter, *b*, so that intra-regional exports as a share of trade $\frac{X^{j,j}}{X^{j,D}+X^{j,j}}$ = .4375, which is the average of that observed in Korea and Thailand in the two years prior to the Asian crisis (see Table 1).

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 (1992), β= .99. The open economy literature uses a range of parameterizations for the elasticity of substitution between goods in multi-good models. We calibrate $\phi=\psi=\gamma=2/3$ which is on the less elastic end of this range, and approximately equal to Reinhart's (1995) estimate of the average elasticity of demand for imports in Asia. The parameter ξ governs the elasticity of substitution between individual retail goods. We set this to achieve a steady state markup of 1.15. The parameter governing the sensitivity of country specific interest rates to debt is set at a very small level; υ = .0004. This ensures that the debt-elastic interest rate produces a stationary equilibrium, but does not affect the response of the model to shocks except at very low frequency.

During the East Asian crisis, central banks raised interest rates drastically during the initial exchange rate depreciations. We set the Benchmark monetary policy at λ_1 = 1.2 and λ_2 = .3. 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 see in Figure 3 that there is a persistent response of macroeconomic aggregates to the East Asian crisis. Accordingly, the model features a persistent shock and a number of dynamic propagation mechanisms including investment and price adjustment costs as well as consumption habit formation. The shock is modeled as an exogenous rise in the regional risk premia. During the East Asian crisis, we observe dramatic increases in HSBC-constructed indices for US dollar bond yields in Korea and Thailand. Country premiums over 3 month

US Treasuries reach a peak of approximately 700 annualized basis points. As such we calibrate a large interest rate shock, $\varepsilon_1 = .0175$ occurring in period 1 indicating an initial rise in the annualized risk premium of 7%. After period 1, there are no further shocks. Premiums on some long-term bonds rise by similar levels indicating a market belief that the shock would be highly persistent. We calibrate the persistence parameter at $\rho = .95$. This is the same figure used in Gertler, Gilchrist, and Natalucci (2001).

The real effects of the East Asian crisis were clearly quite persistent. The model includes a number of dynamic propagation mechanisms intended to capture this persistence, following a shock to the country risk premium, including consumption habit formation, investment adjustment costs, and sticky prices. Consumption habit formation and investment adjustment costs govern both the dynamics of the model as well as the size of the response of consumption and investment demand to the shocks. We set the consumption habit formation parameter is set at h = .5 and the investment adjustment cost is set at $\Phi_K = 1.4$ to roughly match the size of the response of consumption and investment to the shock.

To induce a persistent output response, we assume a relatively large cost of adjusting prices. We set $\kappa = 200$ as in Laxton and Pesenti's (2003) calibration for the United States[6]. To a first order approximation, quadratic adjustment costs produce inflation dynamics similar to those created by Calvo's random staggered pricing model. Our calibration would generate linearized dynamics equivalent to a Calvo model in which prices change on average of every 6 quarters.

V. Results

A. Impulse Response Under the Crisis

In this section, we describe the results of the `crisis' shock in the form of an increase in the external risk premium, measured as described above. We describe the qualitative effects of a rise in the exogenous world risk premium on one economy, e.g. Korea. The effects on the other symmetric 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* (denoted LCP). That is, export prices from Korea to Thailand are set in terms of Thai baht, 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 from the developed world. Thus, import prices rise, and imports fall. This generates a substitution in demand towards domestic goods (and imports from Thailand). But the overall effect is small, since imported goods and home produced goods are relatively poor substitutes, given our calibration.

If, on the other hand, all export prices within the region are set in US dollars (the Benchmark model), then the regional shock has a much greater impact on aggregate demand in Korea. The reason is that Thailand's devaluation will lead to a large 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 causes a much bigger negative impact on Korean GDP.

Quantitatively, we make two comparisons. First, in Figure 3, we show the response of the calibrated benchmark model to a shock, along with the response to the East Asian crisis

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[6] Note however that Laxton and Pesenti (2003) use a slightly different adjustment cost function involving inflation smoothing.

from the data. We show the response of the Benchmark model along with two alternative models: a) an LCP model, in which intra-regional trade is set in the currency of the customer and b) a No Regional Trade model, in which there is no trade between the two small economies (so that we focus on the crisis hitting just one small economy on its own). In the case of the LCP model, we modify the first order condition for optimal export pricing within the region to the following:

$$1-\xi =$$

$$E_{t-1}[-\xi \frac{MC_t^j \big/ S_t^{l\neq j} + \Delta_t^{l.j}}{P_t^{j.l}} - \kappa \frac{\left(P_{t-1}^{l,j} - P_{t-1}^{l,j}\right)}{P_{t-1}^{l,j}} + \frac{\beta}{(1+i_t)} \cdot \left(\frac{S_{t+1}^{l\neq j}}{S_t^{l\neq j}}\right)\left(\frac{X_{t+1}^{l,j}}{X_t^{l,j}}\right) \cdot \left\{\kappa \frac{\left(P_{t+1}^{l,j} - P_t^{l,j}\right)}{P_t^{l,j}} + \kappa \frac{\Delta_{t+1}^{l.j}}{P_t^{l,j}}\right\}] \tag{1.20}$$

where $S_t^{l\neq j}$ is the cross rate between the two East Asian currencies. In the case of the No Regional Trade model, we merely set the parameter $b = 1$.

Figure 3 shows that the Benchmark model largely captures the quantitative response of output, consumption, investment and imports to the crisis. In particular, output decreases by about 10% in the period of the shock and remains persistently below trend for about the same number of periods as does GDP in the data. Investment declines by 50%, consumption by about 9%, and imports by about 25% below steady state. Each of these series reach their trough in periods after the initial period of the shock – i.e. we achieve a hump shaped response to the crisis shock. These declines are quite similar in size and persistence to those observed in the data, though it should be noted that the shocks affect economic activity more quickly in the modeled economy than in the data.

Can the benchmark model explain the aggregate decline in exports observed in the data? Figure 3, Panel E shows that total exports in the Benchmark model decline by about 8%, and remain persistently below trend. This is within the range of the persistent declines in exports observed in Malaysia and Thailand. In the benchmark model exports to the other East Asian economies decline by about 20%. This exceeds the decline observed in Korea and

Malaysia, but is very close to the decline in regional exports observed in Thailand. Exports to the developed world in the model show a slow but steady increase, again similar to that observed in the data (see Panel F).

Can the alternative models capture the decline in exports observed in the data? The evidence in Figure 4, Panel D-G suggests not. Panel G compares the post-crisis response of exports to the developed world in the Benchmark model and in the LCP and No Regional Trade models. In each model, the decline in the relative prices in the small economy results in an increase exports to the developed economy. Because exports to the developed world have sticky prices in dollars, they respond only slowly to the crisis. In the No Regional Trade model, exports to the developed world are the same as total exports. These expand slowly as shown in Panel E. In the LCP model, there is no immediate change in the relative price of regional exports for the importing countries. Regional goods exports decline only due to the general decline in absorption in each economy. As shown in Panel F, this decline is much smaller than in the Benchmark model in which dollar currency pricing implies an immediate increase in the relative price of regional exports. The quantitative implication is that in the LCP model aggregate exports decline by only a small amount, and only very briefly.

Our second quantitative question concerns the degree to which the decline in output in the worst hit crisis countries can be explained by the contraction in regional trade. Panel A of Figure 3 shows the response of output in each of the three models. We observe that output declines by substantially more in the Benchmark model than either the No Regional Trade model or the LCP model. In the LCP model, output declines by slightly more than 5% compared with a decline of about 10% in the Benchmark. Under dollar currency pricing the post crisis devaluation introduces an additional channel which generates substantial propagation of the negative shock. As shown in Panel B, the sharper decline output in the Benchmark model results in a sharper decline in investment than in the LCP models. The decline in output under the No Regional Trade model is just over 6 percent, but still substantially less than the Benchmark model. The No regional trade model is in fact clearly counterfactual, given its predictions for output and export responses. This suggests that regional links are critical in understanding the overall effects of the crisis.

Panels G and H show the response of exchange rates and absorption deflators (which is analogous to the CPI in the model). The model produces a persistent depreciation of the domestic currency relative to the developed economy currency. In the model, the long-run 30% depreciation is within the range of the 25-40% long-run depreciations observed in the data. However, the dynamics differ. In the data, there is a sharp overshooting of the exchange rate, with the initial depreciations approaching 60%. All countries exhibit this initial overshooting. In the model however, the exchange rate adjusts more slowly, as the monetary policy effectively targets a smooth exchange rate growth. By contrast, the model does a fairly good job in matching the short-run response of the absorption deflator. This rises moderately, in both data and model. However, the permanent exchange rate depreciation results in a permanent increase in nominal prices in the model (in which the real exchange rate is stationary). In the data, by contrast, the absorption deflator converges back to its pre-crisis forecast.

B. Alternative Policy Rules

In our model, the depreciations of the currencies of the Asian dollar currency bloc relative to the US dollar played a role in exacerbating the crisis. 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 the crisis would 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 5 shows the response of the two economies under an asymmetric monetary policy rule. The first economy (Korea) uses the benchmark monetary policy from the previous section ($\lambda_1 = 1.2$ and $\lambda_2 = .3$). The second (Thailand) puts more weight on exchange rate stability $\lambda_1 = .75$ and $\lambda_2 = .75$. For comparison, we also show the response under the symmetric benchmark model from the first section.

Clearly, a country that attempts to prevent exchange rate adjustment incurs large immediate costs. Figure 4, Panel G & H show that the exchange rate depreciates and the absorption deflator rises more slowly than in the benchmark case. Since real interest rates must rise by much more, absorption and GDP fall by considerably more for the country that adopts exchange rate stabilization. In particular, GDP falls by about 70 percent more than in the benchmark case, and the recession is much more prolonged.

We also see that the selection of the exchange rate stabilization policy also impacts the partner country in the regional trading bloc. We observe that the exports of the partner actually fall more sharply than in the case in which both countries adopt the benchmark stabilization policy. As a result, the trading partner experiences a slightly greater fall in GDP. There are two determinants of regional exports: 1) the price of regional exports relative to domestically produced goods; and 2) the total absorption of goods (i.e. total demand). If one country stabilizes its exchange rate relative to the dollar, it will also stabilize the first determinant, so that there is no rise in the price of regional imports. However, stabilizing the exchange rate also results in a large contraction in overall absorption. In the calibration in our model, the second effect is larger than the first, implying that a country's exports to a regional trading partner will decline more when that trading partner stabilizes its exchange rate (see Figure 3, Panel F). However, it can be shown that this ranking is reversed if the goods produced by the two trading partners are better substitutes than in this calibration. If the goods produced by the two trading partners are goods substitutes, then the effects of changes in the relative price will have a strong effect on the volume of regional exports. In the case of very close substitutes, a country's exports to a regional trading partner will decline less when that trading partner stabilizes its exchange rate.

VI. Conclusions

We have argued that the collapse in intra-regional trade is an important factor in the quantitative accounting for the East Asian crisis. The crisis was initiated as region-wide fall in capital flows (equivalent in our model to a rise in the world interest rate) which reduced demand and economic activity in all countries. But the importance of regional trade links in East Asia led to a significant magnification of the crisis through a fall in regional exports. Central to this mechanism, in our model, 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. Our results raise the question of why the US dollar is so dominant as a trade currency in East Asia. We leave this for future research.

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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

Table 5 Calibration

Parameter	Number	Source
Government Share G/GDP	**.106**	**Average of numbers for Korea and Thailand from Cook and Devereux**
Capital Intensity Parameter	θ **= .301**	
Debt as a Share of Annual GDP $D/(GDP*4)$	**.275** *(implies* $\overline{D} = 2.7023$*)*	
Exports as a share of GDP $\frac{X^{j,D}+X^{j,j}}{GDP^{j}}$	**.301** *(implies* $s_{D,EA}A_t^D$ *=.832)*	
Regional Exports as a share of GDP $\frac{X^{j,j}}{GDP^{j}}$	**.4375** *(implies b = .1585)*	**Average of Numbers for Korea and Thailand in 1996 (Table 1)**
Imports as a share of GDP $\frac{IM^{j,D}+X^{j,j}}{GDP^{j}}$	**.290** *(implies a = .160)*	**Normalization to get unit real exchange rate**
Time Discount Rate β	**.99**	**Backus, Kydland Kehoe (1992)**
Capital Depreciation Rate, δ	**.205**	
Elasticity of Substitution between East Asian and Developed World Goods ϕ	$2/3$	**Low end of range of plausible substitutability also used in Cook and Devereux (2004)**
Elasticity of Substitution between goods from different East Asian countries γ	$2/3$	
Elasticity of Substitution between individual types of monopolistic goods	$\xi = 7\,2/3$	**Steady State Markups equal to 1.15 as in Bergin and Tchakarov (2004)**
Debt Sensitivity of the Interest Rate υ	**.0004**	**Small so as to have only long run effects.**
Monetary Policy Parameters $\Lambda\lambda_1$ **and** $\Lambda\lambda_1$	λ_1 **= 1.2 and** λ_2 **= .3**	**Cook and Devereux (2004) show that this policy rule does well matching the interest rate response to crisis**
Consumption Habit Formation	**h = .5**	**Trough response of consumption roughly matches the data**
Investment Adjustment Cost	$\Phi_K = 1.4$	**Trough response of investment roughly matches the data**
Price Adjustment Cost	κ **= 200**	**Persistence of output shock roughly matches the data**
Size of Shock	ε_1 **= .0175**	**Matches peak rise in Spread between US Treasuries and HSBC index of bond yields.**
Persistence of Shocks	ρ **= .95**	**Gali, Gertler and Natalucci (2001)**

Figure 1a Korea

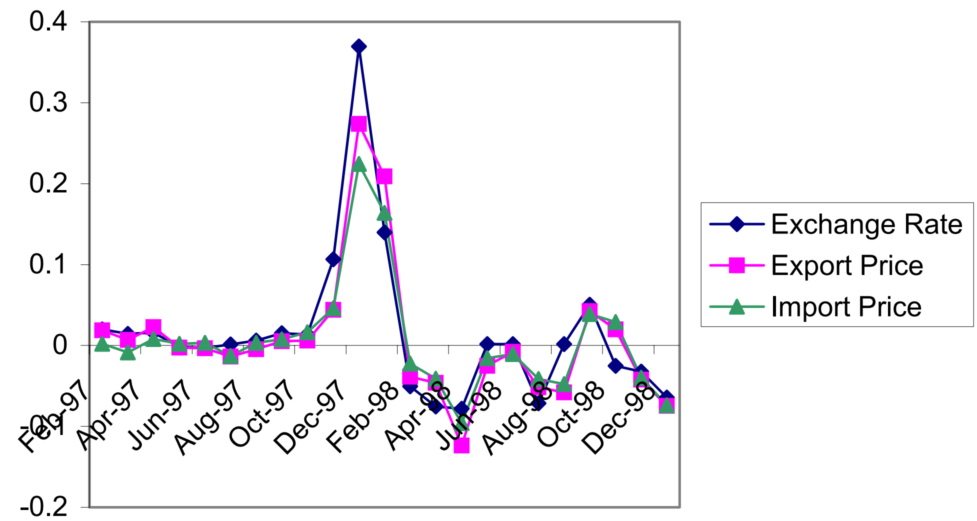
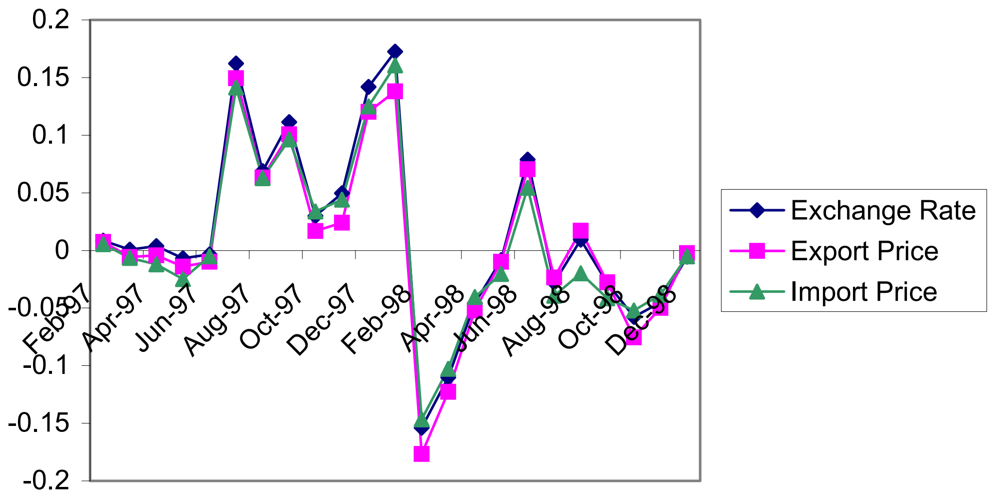


Figure 1b Thailand



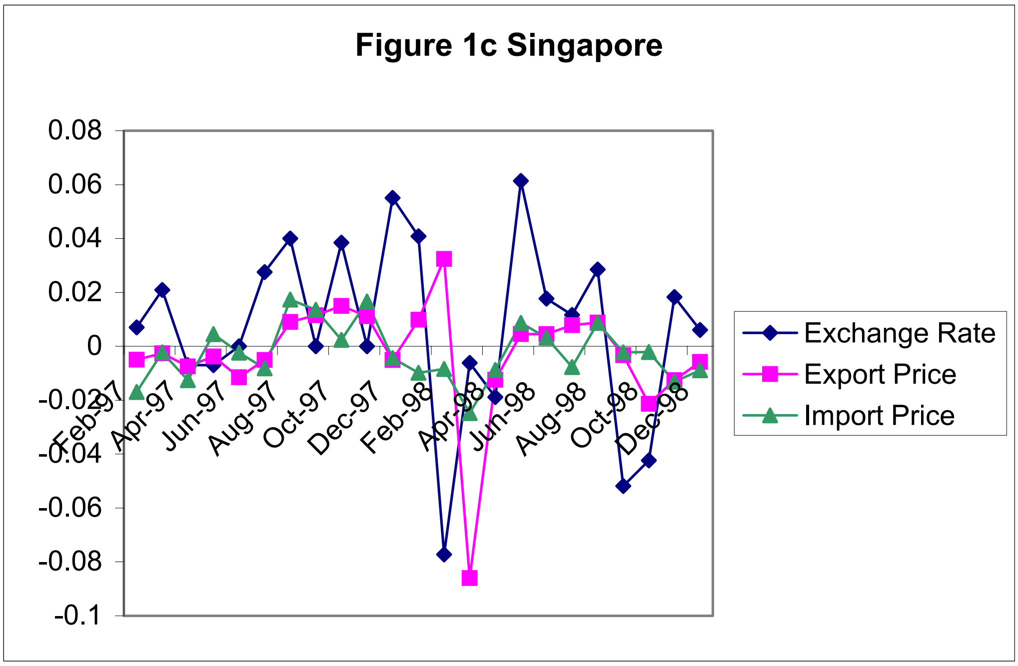


Figure 1c Singapore
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Jun-98
Aug-98
Oct-98
Dec-98
Exchange Rate
Export Price
Import Price

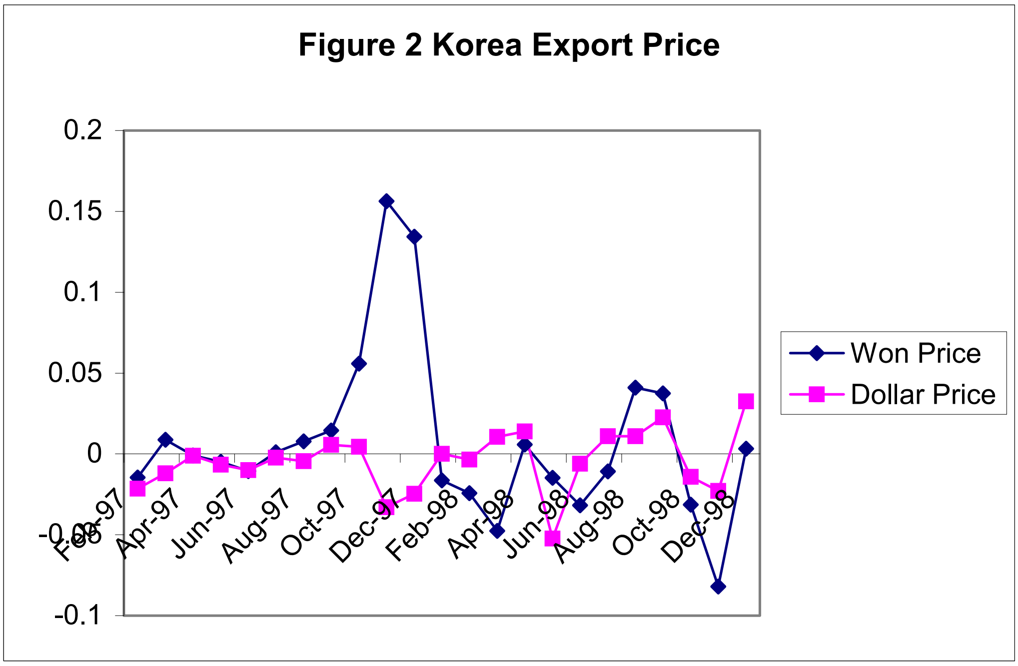


Figure 2 Korea Export Price
0.2
0.15
0.1
0.05
0
-0.05
-0.1
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Jun-98
Aug-98
Oct-98
Dec-98
Won Price
Dollar Price

Figure 3: Data

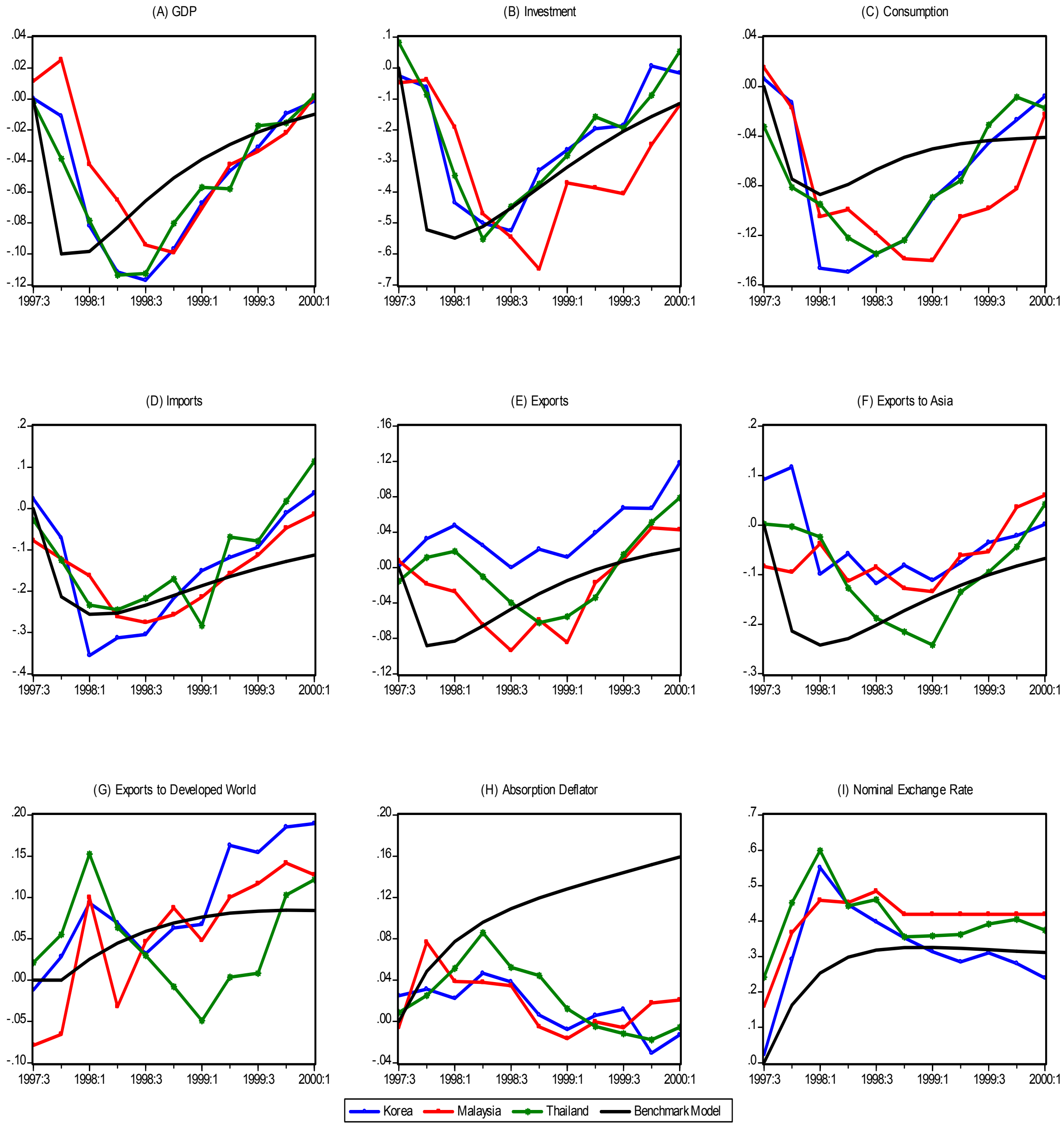


Figure 4: Response of Models to Shocks

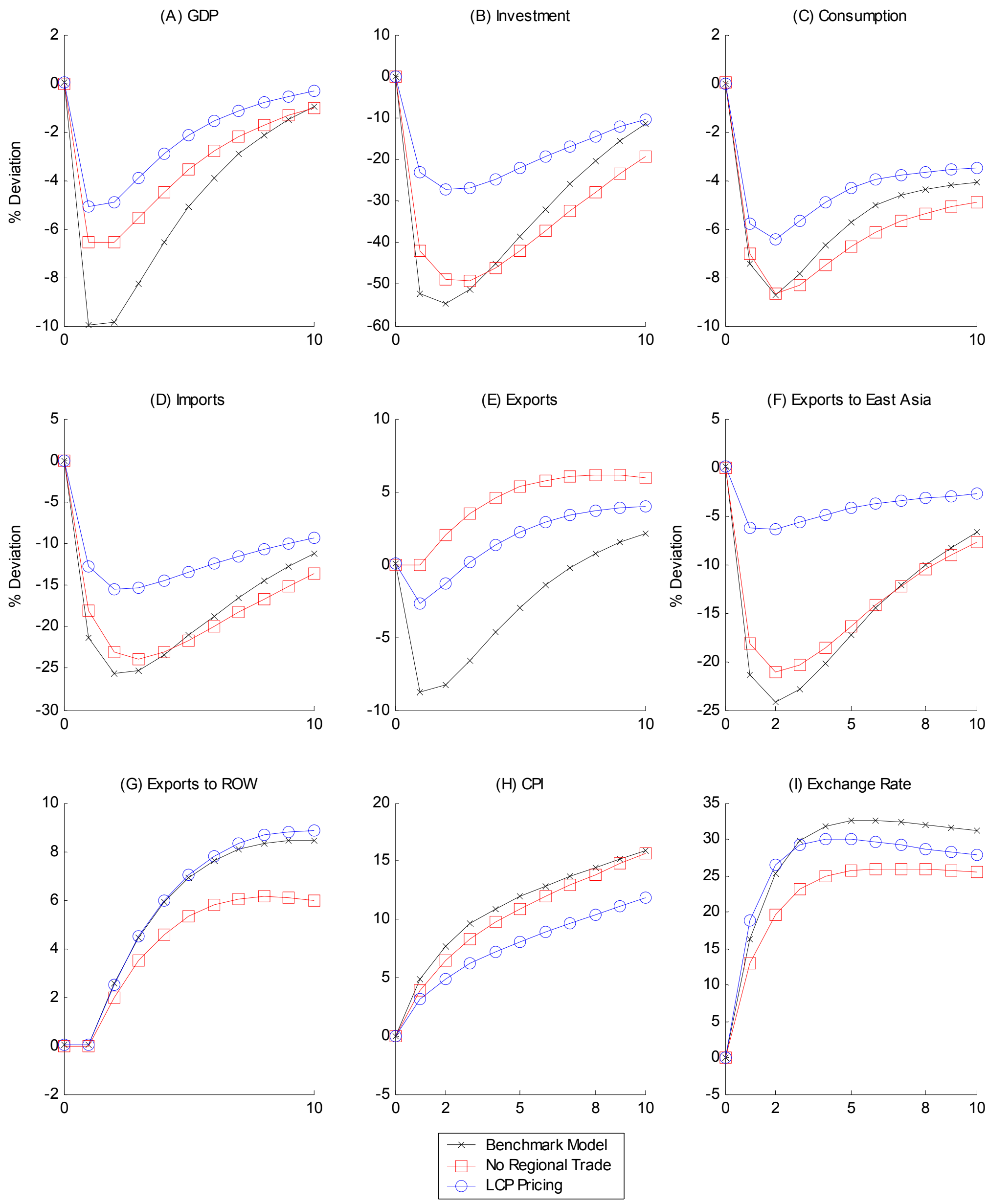


Figure 5 Fixed Exchange Rates vs. Benchmark Monetary Policy