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Abstract

This paper studies the behavior of inflation after nine large post-1990 contractionary devaluations. A salient feature of the data is that inflation is low relative to the rate of devaluation. We argue that distribution costs and substitution away from imports to lower quality local goods can account quantitatively for the post-devaluation behavior of prices.

Keywords: inflation, devaluation, exchange rates.

J.E.L. Classification: F31

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1. Introduction

This paper studies the behavior of inflation and real exchange rates after large, contractionary devaluations.[1] These episodes are a useful laboratory for exploring the sources of real exchange rate fluctuations because nominal price rigidities are less likely to play a major role in inflation dynamics.[2] Our analysis proceeds in two steps. First we document some key facts about the behavior of prices in the aftermath of nine large post-1990 contractionary devaluations. Second, we argue that distribution costs and substitution in consumption away from imports to lower quality local goods can account quantitatively for the post-devaluation behavior of prices. We make this argument via a series of price accounting exercises and a quantitative general equilibrium model.

Our empirical work is based on data from Finland, Sweden, Mexico, Korea, Thailand, Malaysia, Philippines, Indonesia, and Brazil. Six key facts about the behavior of prices emerge from our analysis:

1. Consistent with the evidence in Mussa (1986), the rate of inflation, as measured by the consumer price index (CPI), is very low relative to the exchange rate depreciation.

2. The rate of CPI inflation is low for both tradable and nontradable goods.

3. The price of nontradable goods, relative to tradable goods, falls after large devaluations.

[1] For other recent empirical studies of the behavior of inflation after large devaluations see Borensztein and De Gregorio (1999) and Goldfajn and Werlang (2000). Amitrano, de Grawe, and Tullio (1997) and Gordon (2000) analyze the behavior of inflation after the break-up of the ERM in 1992.

[2] There is a large literature on the importance of nominal rigidities for understanding the effects of moderate changes in the exchange rate. See Goldberg and Knetter (1997) for a survey of the exchange rate pass-through literature and Campa and Goldberg (2001) for some recent empirical work.

4. The prices of imports and exports move much more closely with the exchange rate than the CPI.

5. Inflation, as measured by the wholesale price index, is higher than CPI inflation but lower than the rate of change in the price of exports and imports.

6. The behavior of the CPI is similar whether or not we include goods whose price is heavily influenced by the government.

Finally, in all of the episodes which we consider, real GDP growth falls after a large devaluation and there is a large rise in the trade surplus.[3] This rise is accomplished by a large decline in real imports and a substantial, but smaller, rise in real exports. A successful explanation of why inflation is so low after large devaluations ought to be consistent with these observations.

To motivate our explanation of these facts we engage in the following 'price accounting' exercise. We take as given from the data the price of nontradable goods as well as the weight that they receive in the official CPI basket. We assume, as in the standard two sector model, that purchasing power parity (PPP) holds for tradable goods.[4] Then we compute the CPI and ask whether the implied rate of inflation is consistent with that observed in the data. The answer is no. For example, in the case of Korea these assumptions imply that inflation in the first year after the devaluation should have been 22.7 percent, as opposed to the 6.6 percent observed in the data.

Next we assume that the retail sale of tradable goods requires distribution services (transportation, wholesaling and retailing) and that the rate of change in the cost of distribution services coincides with the rate of inflation in nontradable goods. This brings the implied rate of inflation substantially closer to the

[3] In all the episodes that we consider except Brazil the level of real GDP actually falls.

[4] See Obstfeld and Rogoff (1996) for an exposition of the standard tradables-nontradables model.

one observed in the data. For example, the implied rate of inflation for Korea equals 14.1 percent. It is important to note that the way we introduce distribution services is not equivalent to simply increasing the weight of nontradables in the standard tradables-nontradables model. This is because the presence of distribution services implies that PPP no longer holds for tradable goods. As we discuss in the text, it is possible to match CPI inflation by increasing the share of nontradables in the standard model. But this version of the model cannot account for the observed change in the price of tradable goods. As a consequence it greatly overstates the decline in the relative price of nontradable goods.

Next, we assume that some goods which are traditionally classified as tradable are in practice local goods that are produced solely for the domestic market as an inferior substitute for imported goods (e.g. local wine versus French wine). This further reduces the implied rate of inflation, which falls to 11.3 percent in the Korean case.

The final step in our price accounting exercise is to assume that the share of local tradable goods rises in the wake of a devaluation. In principle this 'flight from quality' should not affect measured inflation since the CPI measures the price of a fixed bundle of goods. However, in practice the individual items that comprise the CPI basket are replaced to reflect changes in consumption patterns. For reasons discussed in section 3 this may impart a significant downward bias in measured inflation. We find that under reasonable assumptions about the extent of 'flight from quality' and its impact on the CPI, we can fully account for observed inflation rates.

Based on these results we conclude that, given a low inflation rate in nontradable good prices, distribution costs, local goods and 'flight from quality' imply a low rate of CPI inflation. So the challenge is: can we generate 'flight from quality' and low nontradable good price inflation as equilibrium phenomena?

We attack this problem using a standard flexible price neoclassical model of tradable and nontradable goods extended to allow explicitly for distribution services and local goods. We imagine that at some time zero, there is a tightening of the external borrowing constraint for both the government and private agents. Under our assumptions about fiscal policy, the government responds to this shock by resorting to seigniorage revenues. This generates a large depreciation of the exchange rate. At the same time, the shock to the private agents' borrowing constraint implies that the trade surplus of the country must rise.

In our model this is accomplished by two mechanisms. First, agents reduce the level of imported consumption goods. Given our assumption that the marginal utility of nontradable goods is increasing in tradable good consumption and that local goods are inferior substitutes for imported consumption goods, it is optimal for private agents to substitute towards local goods, i.e. there is 'flight from quality'. Second, agents reduce the production and consumption of nontradable goods and use the corresponding resources to increase the production of exported goods. Because certain factors like capital are fixed in the short run, the marginal (dollar) cost of producing nontradable goods is an increasing function of total output. Other things equal, the fall in the production of nontradable goods induces a decline in their dollar price. This is the basic force in our model that mutes the post-devaluation rise in the domestic currency price of nontradable goods. The critical question that we address is whether this force is large enough to account for our empirical observations.

To address this question we calibrate our model using data from Korea and Mexico. For both countries we find that our model is consistent with the behavior of prices in the aftermath of a devaluation. In addition the model can account for the large rise in exports, the large fall in imports, and the substitution towards local goods that occurs after the devaluation.

While successful along a number of dimensions, the benchmark model has at least two important shortcomings: it substantially overstates the extent of the post-devaluation rise in exports as well as the extent to which the tradeable good sector expands relative to the nontradable sector. In our view this reflects the absence of credit market frictions in the benchmark model. Fully modeling these frictions lies beyond the scope of this paper. Instead we assess the robustness of our inflation results by mimicking the effects of credit market frictions in a reduced form. Specifically, we assume that total factor productivity in the tradable good sector falls after the devaluation. We find that our inflation results are robust to allowing for these frictions. In addition, the model's implications for sectoral outputs are dramatically improved. For example, in the case of Mexico the model is now able to account for the fall in the output of both the tradable and nontradable sector, as well as the overall decline in real GDP.

The remainder of the paper is organized as follows. Section 2 documents the key facts about price behavior in the aftermath of large devaluations. Section 3 contains our 'price accounting' exercise. Section 4 discusses our model. Section 5 provides some conclusions.

2. The Behavior of Prices in the Aftermath of Large Devaluations

To document the behavior of prices in the wake of large devaluations we investigate data drawn from nine episodes: Sweden (1992), Finland (1992), Mexico (1994), Korea (1997), Thailand (1997), Malaysia (1997), Indonesia (1997), Philippines (1997), and Brazil (1999). All these episodes feature annual rates of devaluation versus the US dollar in excess of 38 percent. In figures 1 to 9 and table 1 we summarize the behavior of twelve variables: the dollar exchange rate, the effective (trade weighted) exchange rate, the CPI rate of inflation, the rate of inflation for the tradable and nontradable component of the CPI basket, the rate of inflation in import and export prices as well as wholesale prices, a tradable price index compiled using price information collected for different countries by Runzheimer International, an index of the price of apparel goods included in the CPI, an index of the price of apparel goods constructed using data from Runzheimer International and an index of good prices that are heavily influenced by the government.[5]

Six of the twelve variables that we display were obtained directly from country sources.[6] We constructed tradables and nontradables price indices using disaggregated CPI data together with our classification of goods into tradables and nontradables. While there is an unavoidable element of subjectivity in this classification, it is worthwhile noting that in most countries the most important nontradable goods are fairly uncontroversial. These goods are housing, education, health, and transportation. We also constructed a tradables good index based on data from Runzheimer International. This is a company that surveys prices in different countries to compute cost-of-living indexes that are used to calculate compensation for workers who are reallocated to a different country. Two virtues of this data set are that Runzheimer tries to keep constant the quality of the products surveyed and tends to exclude local goods.[7] Since we do not have information about the weights attached to individual items in the CPI, our Runzheimer index is a simple average of prices. For this reason we also used the Runzheimer data to construct a price index of apparel goods which can be directly compared with the apparel component of the CPI. We constructed a price index of goods that

[5] All our calculations use continuously compounded rates of change.

[6] Detailed data sources are summarized in an appendix available from the authors upon request.

[7] The cost of living division of the United Nations produces an index analogous to Runzheimer for its employees. This index is less suitable for our purposes because it assumes that some goods are purchased out-of-area in foreign currency. Nevertheless, we found that inference using the United Nations and the Runzheimer price index was similar.

are heavily influenced by the government. Examples of such goods include public transportation, utilities and some components of the health and education categories. Finally, we constructed measures of the effective nominal exchange rate by weighting the nominal exchange rate of different countries according to the average shares of exports plus imports computed over a period of three years.

The six main facts that emerge from this data were summarized in the introduction. First, CPI inflation is very low in the aftermath of a devaluation. For example, in Korea the US dollar/Won exchange rate depreciated by 41.2 percent between September 1997 and September 1998. In sharp contrast, CPI inflation was only 6.6 percent. Second, both tradables and nontradables inflation is low. For example, between September 1997 and September 1998, the Won price of tradable and nontradable good prices rose by 8.2 percent and 5.1 percent respectively. Third, tradable goods inflation as measured by the Runzheimer index is significantly higher than the tradable goods inflation implicit in the CPI. When we restrict attention to a category of goods that is more directly comparable between the two data sources–apparel–we also find that the rate of inflation computed with the Runzheimer data is generally higher than that computed using the official CPI data. Based on these findings as well as the CPI based numbers, we infer that the price of nontradables relative to tradables goods falls after a large devaluation. Fourth, the prices of imports and exports move much more closely with the exchange rate than the CPI.[8] Fifth, inflation, as measured by the wholesale price index, is higher than CPI inflation but lower than the rate of change in the price of exportables and importables. This suggests that PPP is likely to be a better approximation for producer prices than for the retail prices that are used to construct the CPI. It also suggests that a satisfactory theory of

[8] Most of Finland and Sweden's trade is with its European neighbors. So the relevant exchange rate to focus on for these countries is the effective exchange rate.

the consequences of large devaluations will have to come to grips with the wedge between observed rates of inflation at different stages of distribution. Sixth, the rate of CPI inflation does not depend very much on whether we include goods and services whose prices are heavily influenced by the government.

Finally, table 2 displays the behavior of various economic aggregate variables. Among other things, this table indicates that, after a large devaluation, real GDP and real consumption declines, while the trade balance switches from a deficit to a surplus. Note that the latter is accomplished via a large decline in real imports and a substantial, but smaller, rise in real exports.

3. Price Accounting

In this section we engage in a series of price accounting exercises to motivate the key features of the structural model discussed in section 4. Specifically, we will argue that allowing for nontradable goods and distribution services is essential to generate realistic rates of inflation and movements in the relative price of nontradable goods.

We proceed in three steps. First, we compute the CPI taking the price of nontradable goods from the data and imposing the assumption that PPP holds for tradable goods. Second, we allow for distribution services in tradable goods. Third, we introduce local goods and 'flight from quality'. We undertake this price accounting exercise for the six countries for which we have disaggregated price data. Our results are reported in table 3. To conserve on space, we concentrate our discussion on the behavior of inflation rates in the first year after the devaluations in Korea and Mexico. The results for cumulative inflation rates two years after the devaluations follow a similar pattern (see table 3).

It is useful to begin by considering a benchmark case in which all goods are tradable and PPP holds. In this case the domestic CPI (P_t) is given by:

$$P_t = S_t P_t^*,$$

where S_t is the exchange rate defined as units of domestic currency per US dollar and P_t^* is an index of foreign prices. To minimize the impact of nontradable US goods in our analysis we measure P_t^* as the US producer price index.

Table 3 shows that the Won depreciated by 41.2 percent and the US PPI fell by 3 percent in the first year after the devaluation. So the benchmark model predicts that inflation should have been 38.2 percent. In fact the actual rate of inflation in Korea was only 6.6 percent in the first year following the October 1997 devaluation. The analogue numbers for Mexico are 83.1 percent and 39.5 percent. Clearly the benchmark model does a poor job at accounting for the response of inflation to a large devaluation.

Step 1: Economy with nontradable goods

We now introduce nontradable goods into the analysis and assume that PPP holds for the price of tradable goods (P_t^T):

$$P_t^T = S_t P_t^{T*}.$$

The CPI (P_t) is now a weighted average of the price of tradables and nontradables (P_t^{NT}):

$$P_t = w^T P_t^T + (1 - w^T) P_t^{NT}. \tag{3.1}$$

Here w^T is the fixed weight associated with tradables in the CPI. Both w^T and P_t^{NT} were constructed using disaggregated CPI data. Table 3 summarizes the rates of inflation implied by equation (3.1).

Notice that, for all countries, allowing for nontradable goods reduces substantially the implied rates of inflation. Nevertheless, inflation is still much higher than that observed in the data. For example, for Korea the implied rate of inflation in the first year after the devaluation is 22.3 percent, as opposed to the 6.6 percent observed in the data. The analogue numbers for Mexico are 62.4 and 39.5. Since we are taking the price of nontradables from the data, our failure to reproduce the observed CPI inflation stems from the fact that PPP does not hold for tradable goods. This may reflect the fact that many goods which are classified as tradable actually include a substantial nontradable component. This motivates our next step.

Step 2: Add distribution costs

The CPI is computed using retail prices. These prices are necessarily different from producer prices because they reflect the costs associated with transportation, wholesaling and retailing. Burstein, Neves and Rebelo (2001) provide evidence that suggests that distribution costs are large. They account for roughly 40 and 60 percent of the retail price of consumer goods in the US and Argentina, respectively. Since distribution services are intensive in local labor and land they are likely to be at least partly responsible for the fact that PPP does not hold for the retail price of tradable goods.[9]

To generate an estimate of how distribution services impact on measured inflation rates, we make the following assumptions. First, PPP holds for the producer prices of tradable goods ($\bar{P}_t^T$),

$$\bar{P}_t^T = S_t \bar{P}_t^{T*},$$

where $\bar{P}_t^{T*}$ is the foreign producer prices of tradable goods. Second, consumption of one unit of tradables requires ϕ units of distribution services. Third, the change

[9] Dornbusch (1989) argues that the presence of distribution costs is important for explaining why prices of comparable goods are higher in rich countries than in poor countries.

in the price of distribution coincides with the rate of inflation for nontradables goods. Fourth, consumption of nontradables does not require distribution services. We calibrated ϕ so that the distribution margin, defined as:

$$\text{Distribution Margin} = \frac{\text{Retail Price - Producers Price}}{\text{Retail Price}},$$

is 50 percent in the period before the devaluation. In addition we set the change in $\bar{P}_t^{T*}$ equal to US PPI inflation.

Under our assumptions, the retail price of tradable goods is:

$$P_t^T = S_t + \phi P_t^{NT}, \tag{3.2}$$

and the CPI is given by:

$$P_t = w^T(S_t + \phi P_t^{NT}) + (1 - w^T)P_t^{NT}. \tag{3.3}$$

From table 3 we see that allowing for distribution services generates inflation rates that are substantially closer to the ones observed in the data. For example, equation (3.3) implies inflation rates in Korea and Mexico of 14.1 and 48.2 percent, respectively. While this is a significant improvement relative the non-distribution case the implied rates of inflation are still counterfactually high.

We conclude this subsection by emphasizing that introducing distribution costs is not equivalent to simply increasing the weight given to nontradable goods, $1-w^T$. The standard tradable-nontradable goods model generates a CPI inflation rate for Korea (Mexico) equal to 14.1 percent (48.2 percent) if w^T is set equal to 0.76 (0.73). But that model also implies that the retail price of tradable goods would have risen by 38.2 (83.1) percent. With distribution services, tradable good prices would have risen by only 23.0 (60.6) percent. Since tradable good prices only rose by 8.2 (45.6) percent in the data, we conclude that allowing for distribution services represents a distinct improvement over the standard tradable-nontradable goods model.

Step 3: Add local goods

We now analyze the impact of the presence of local goods and 'flight from quality' on measured rates of CPI inflation. As discussed in the introduction, local goods are usually classified as tradable but are produced solely for domestic consumption as inferior substitutes for imported products. Thus their producer price is determined solely by domestic considerations and need not adjust one to one with the exchange rate.[10]

In the devaluations that we study there was a fall in the growth rate of real GDP. Under these circumstances it is reasonable to assume that consumers would find it optimal to substitute away from high quality imported goods. While the evidence regarding this 'flight from quality' is at this point mostly anecdotal, it suggests that this phenomenon is quite significant. For example, Cho and Advincula (1998) reported that following Korea's 1997 devaluation: "Department stores are switching from imported goods to cheaper local products to lower merchandise prices. Department stores are increasing floor space to display low and medium-priced goods produced in Korea, such as home electronics and groceries, while decreasing floor space for imported and luxury goods. [...] Some department stores are also planning to replace promotional events for imports with exhibitions that feature goods manufactured by local small and medium-sized businesses."

In principle the CPI measures the price of a fixed basket of goods so it should not be affected by 'flight from quality'. And, in fact, the weights attached to different product categories in the CPI are kept constant over relatively long periods of time. However, the individual items that are surveyed within each product category are periodically replaced to reflect changes in demand and product

[10] These local goods are typically not branded. Interestingly, Crucini, Telmer and Zachariadis (2001) find, using European data, that PPP is a better approximation for branded goods than for non-branded goods.

turnover.[11] When a product is replaced the difference between the price of the new and the old product must be decomposed into a pure price effect and a quality difference effect. It is well known that this decomposition can have a significant impact on measured inflation. For example, Armknecht and Weyback (1989) and Moulton and Moses (1997) document that in the US: (i) while the percentage of items replaced is small, it contributes significantly to measured inflation; and (ii) CPI growth rates are substantially affected if differences in quality between old and replacement items are ignored. These quality measurement problems, which are significant at low frequencies in a low inflation country such as the US, are likely to be exacerbated in the aftermath of large devaluations. This is because in these episodes there are large shifts in consumption patterns which induce rapid product replacement.

Countries differ with respect to how frequently individual items and brands are replaced in the CPI bundle. These differences affect how rapidly the CPI basket responds to changes in demand patterns. To see how product replacement can affect the CPI we now contrast a 'fixed brand' system in which 'flight from quality' does not affect measured inflation, with different systems in which brands are allowed to vary.[12]

In computing the price index for a given category of tradables the price inspector must decide how much weight to give to each brand of a given type of good. In the 'fixed brand' method these weights are held constant at a benchmark value, w_0^L. Abstracting from aggregation across categories, the price of tradable

[11] One example of the impact of product turnover on the CPI relates to the treatment of missing items. According to the IMF's Special Data Dissemination Standards Site, in some countries, such as Thailand, when an item is missing from the shelf the price inspector records the price of that item in the previous period. This can obviously result in artificial price stickiness.

[12] The 'fixed brand' system underestimates inflation if 'flight from quality' occurs at the level of intermediate goods. If producers reduce the quality of their inputs this lowers the quality of the final products in a way that is unlikely to be taken into account in the measurement of the CPI.

goods is then given by the weighted average of the retail price of local goods (P_t^L) and imported goods (P_t^I):

$$P_t^T = w_0^L P_t^L + (1 - w_0^L) P_t^I.$$

Since w_0^L is constant, shifts in consumption patterns across brands affect P_t^T only through their direct influence on P_t^L and P_t^I. In contrast, under a 'variable brand' system measured inflation depends critically on how product replacement is handled.

To illustrate the issues that can arise we consider three possibilities. Under 'variable brand 1' method the weight attached to a given brand in period t is equal to its market share in period t, so that:

$$\begin{aligned} P_0^T &= w_0^L P_0^L + (1 - w_0^L) P_0^I, \\ P_1^T &= w_1^L P_1^L + (1 - w_1^L) P_1^I. \end{aligned}$$

The price of tradable goods at time 1 can be re-written as:

$$P_1^T = w_0^L P_1^L + (1 - w_0^L) P_1^I + (w_1^L - w_0^L)(P_1^L - P_1^I).$$

The first part of this expression, $w_0^L P_1^L + (1 - w_0^L) P_1^I$, corresponds to the CPI as measured by the 'fixed brand' method. The last term, $(w_1^L - w_0^L)(P_1^L - P_1^I)$, reflects the bias introduced by brand substitution. Note that if consumers substitute towards local goods after the devaluation ($w_1^L > w_0^L$), and local goods are cheaper than imported goods ($P_1^L < P_1^I$), then measured CPI inflation will be lower than under the 'fixed brand' method. If local goods are of lower quality than imported goods 'variable brand 1' method may grossly understate inflation. So an important implicit assumption underlying this method is that local and imported goods are of similar quality. 'Variable brand 2' method abandons this assumption and fully attributes any differences in the price of local and imported goods to differences in quality. Here the CPI is computed according to:[13]

$$\begin{aligned} P_0^T &= w_0^L P_0^L + (1 - w_0^L) P_0^I, \\ P_1^T &= w_0^L P_1^L + (w_1^L - w_0^L) P_0^I \frac{P_1^L}{P_0^L} + (1 - w_1^L) P_1^I. \end{aligned}$$

Notice that the rate of change in the price of the local good (P_1^L / P_0^L) is used to update the price of the imported good. The expression for P_1^T can be rewritten as:

$$P_1^T = w_0^L P_1^L + (1 - w_0^L) P_1^I + (w_1^L - w_0^L) P_1^I \left(\frac{P_1^L / P_0^L}{P_1^I / P_0^I} - 1 \right).$$

This method introduces a more subtle measurement bias than 'variable brand 1'. Measured CPI inflation is biased downward relative to the 'fixed brand' method whenever households substitute toward local goods and the increase in the price of these goods (P_1^L / P_0^L) is lower than the increase in the price of imported goods (P_1^I / P_0^I).

The most extreme version of the bias introduced by 'flight from quality' emerges under the method we refer to as 'variable brand 3'. Here only the brand that sells the most is sampled and there are no adjustments for differences in quality between the local and the imported good. Suppose that in the base year, time period zero, consumers bought predominantly imported goods of a given category such as wine. Now suppose that in period one consumers switch to buying mostly local bands. Under the 'variable brand 3' method the price of tradable goods is computed according to: $P_0^T = P_0^I$, $P_1^T = P_1^L$.

[13] This formula assumes that $w_1^L > w_0^L$. When $w_1^L < w_0^L$ the analogous formula is: $P_1^T = (1 - w_0^L) P_1^I + (w_0^L - w_1^L) P_0^L (P_1^I / P_0^I) + w_1^L P_1^L$.

Results with 'Fixed' and 'Variable' Brand Methods

The results summarized in table 3 were generated under two assumptions: (i) the rate of change in the price of local goods coincides with nontradable inflation; and (ii) local goods have the same distribution requirements as imported goods. While there is considerable uncertainty about the initial share of local goods, we assume that w_0^L is 40 percent. This is consistent with the parameters used to calibrate our structural model (see section 4). It is also in the range of estimates for the market share of supermarket generic products versus premium brands obtained by AC Nielsen (2001a) in a recent study of five Latin American countries. In addition we assume that $P_0^L/P_0^I = 0.70$ which is consistent with the AC Nielsen evidence from Latin America discussed in section 4.

Table 3 indicates that allowing for local goods under the 'fixed brand' method leads to moderately lower rates of inflation. In the case of Korea the implied rate of inflation in the first year falls from 14.1 to 11.3 percent. In the case of Mexico inflation falls from 48.2 to 43.2 percent.

To implement the 'variable brand' methods we need to make an assumption about the share of local goods after the devaluation (w_1^L). In the model of section 4 w_1^L is endogenous. Here we assume for illustrative purposes that $w_1^L = 0.5$, so this share increases by 10 percentage points after the devaluation. Given the uncertainty associated with the parameters used in these calculations we conduct some sensitivity analysis in table 4.

Not surprisingly, table 3 shows that local goods have the most dramatic impact on inflation under 'variable brand' 3 method. In the case of Mexico, CPI inflation is 14.1 percent, far below measured inflation (39.5). Even more dramatically, inflation in Korea is negative (-10.4 percent). Local goods have the smallest impact on inflation under 'variable brand 2'. Here the implied rates of inflation for Korea and Mexico are 10.3 and 41.3 percent, respectively. Finally, in the intermediate case given by 'variable brand 1', the rate of inflation for Korea and Mexico is 8.7 and 39.7 percent, respectively.

Based on these results we conclude that measurement error due to local goods does not play a large role in Mexican case. The implied rate of inflation generated by the 'fixed brand' method is very close to the actual rate of inflation observed in Mexico. This is consistent with our prior information that CPI collection methods in Mexico are well described by the 'fixed brand' method.[14] In contrast, our calculations suggest that measurement error associated with local goods plays a relatively larger role in accounting for Korean inflation rates. This is consistent with our prior information about CPI collection methods in Korea.[15] In any event table 3 indicates that the 'variable brand' methods generate more realistic inflation rates for all countries.

The Runzheimer data is also consistent with the notion that the measurement error induced by local goods and 'flight quality' is important in Korea but not in Mexico. In Korea the tradable component of the CPI rose by 8.2 percent in the first year after the devaluation. In contrast, the Runzheimer tradable price index rose by over 27 percent. A similar pattern emerges when we look at apparel prices. According to the CPI these prices grew by 2.8 percent, while the Runzheimer measure grew by over 25 percent. So controlling for local goods and 'flight from quality' has a large impact on reported rates of inflation. The story is quite different for Mexico. Reported inflation rate for apparel and tradable goods are similar for both CPI and Runzheimer-based measures.

[14] The list of goods used to computed the CPI in Mexico was updated in February 1995. This update had been planned for months and was unrelated to the devaluation. Using several issues of the Diario Oficial de la Federacion for 1995 we concluded that between February and July only 233 goods out of 5494 were added to the CPI basket for Mexico city. Only a fraction of the 233 new goods were introduced to reflect changes in consumption patterns.

[15] Our institutional information about price collection practices in Mexico and Korea is based on information posted on the IMF's Special Data Dissemination Standard Site and on private correspondence with staff members of the statistical agencies in these countries.

Viewed overall our results indicate that, conditional on the presence of distribution services and local goods, the puzzle of why CPI inflation rates are so low after a large devaluation reduces to the question: why is the rate of inflation in nontradable prices so low?

4. A General Equilibrium Model

We now introduce a general equilibrium model that allows us to articulate our explanation for why inflation is so low in the aftermath of a large devaluation. In our model the basic force that produces a fall in the price of nontradables and 'flight from quality' in consumption is the tightening of borrowing constraints triggered by a sudden stop in capital flows to the country.

There are four production sectors in the model: the exportable good sector, the local goods sector, the nontradables sector, and the distribution sector. Variables that pertain to these sectors are indexed by E, L, NT, and D, respectively. All production sectors use capital and labor. The exportable, local and nontradable good sectors also use imported materials according to a Leontieff specification. We denote the materials used in sector i by $Z_{i,t}$. We included imported materials in our specification because they are important in countries such as Korea and can potentially have a significant effect on the CPI.

We denote by K_i and N_i the quantity of capital and labor in sector i. Since we are interested in the short term impact of a devaluation we treat the capital stock as fixed in each sector. Capital can be reallocated among firms of the same sector but it cannot be reallocated across sectors. For this reason the rental price of capital in sector i, $R_{i,t}$, is sector specific. Since we assume that labor is freely mobile, the nominal wage, denoted by W_t, is equalized across sectors.

Output Producing Firms

The problem for a firm in sectors E, L, and NT is given by:

$$\begin{aligned}\Pi_{i,t} &= \max_{K_{i,t},N_{i,t},Z_{i,t}} \bar{P}_{i,t}Y_{i,t} - W_t N_{i,t} - R_{i,t}K_{i,t} - \theta_i \bar{P}_{Z,t} Z_{i,t}, \\ Y_{i,t} &= \min\{A_i K_{i,t}^{1-\alpha} N_{i,t}^{\alpha}, Z_{i,t}/\theta_i\}.\end{aligned}$$

Here $\Pi_{i,t}$ denotes nominal profits in sector i, $\bar{P}_{i,t}$ is the nominal producer price of good i, θ_i is the materials requirement for production of good i, and $\bar{P}_{Z,t}$ is the price of materials.

Distribution Sector

Selling a unit of good $i = E, I, L$ requires ϕ_i units of distribution services. Here I denotes an importable good. These services are produced according to a Cobb-Douglas production function that combines capital and labor. The problem faced by a retailer can be written as:

$$\begin{aligned}\Pi_{D,t} &= \max_{K_{D,t},N_{D,t},X_{E,t},X_{I,t},X_{L,t}} \sum_{i=E,I,L} (P_{i,t} - \bar{P}_{i,t})X_{i,t} - W_t N_{D,t} - R_{D,t}K_{D,t} \\ \sum_{i=E,I,L} \phi_i X_{i,t} &= A_D (K_{D,t})^{1-\alpha} (N_{D,t})^{\alpha},\end{aligned}$$

where $P_{i,t}$ and $X_{i,t}$ denote the retail price and the number of units sold of good i, respectively. The retailer buys $X_{i,t}$ units of good i from the producer at price $\bar{P}_{i,t}$ and sells them to households at a price $P_{i,t}$. Since nontradables do not require distribution services, $P_{NT,t} = \bar{P}_{NT,t}$.

The first order conditions for the distributer's problem imply:

$$P_{i,t} = \bar{P}_{i,t} + \phi_i P_{D,t}, \quad i = E, I, L,$$

where $P_{D,t}$ denotes the marginal cost of distribution, given by:

$$P_{D,t} = \frac{W_t}{\alpha A_D (K_{D,t})^{1-\alpha} (N_{D,t})^{\alpha-1}}.$$

PPP Assumptions

PPP is assumed to hold for the producer price of export goods ($\bar{P}_{E,t}$), import goods ($\bar{P}_{I,t}$), and materials ($\bar{P}_{Z,t}$) so that:

$$\begin{aligned} \bar{P}_{I,t} &= S_t \bar{P}^*_{I,t} \\ \bar{P}_{E,t} &= S_t \bar{P}^*_{E,t} \\ \bar{P}_{Z,t} &= S_t \bar{P}^*_{Z,t} \end{aligned}$$

The Household's Problem

Households inelastically supply one unit of labor in every period. In addition, they maximize lifetime utility defined over sequences of consumption and real balances:

$$U = \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\sigma} - 1}{1-\sigma} + \log(M_{t+1}/\tilde{P}_t) \right\},$$

where M_t denotes beginning of period t household nominal money holdings. The variable C_t denotes consumption services, given by

$$C_t = (C_L + C_H)^{\gamma_L} (C_{NT})^{1-\gamma_L-\gamma_H} C_H^{\gamma_H},$$

where C_{NT} denotes consumption of nontradable goods and C_L denotes consumption of a lower quality local tradable good. The variable C_H represents a high-quality tradable good which is a composite consumption service derived from the consumption of exports (C_E) and imports (C_I). According to this specification C_L and C_H are substitutes. For convenience we assume that C_H is related to C_I and C_E according to a Cobb-Douglas function:[16]

$$C_H = C_I^{1-\lambda} C_E^{\lambda}, \qquad 0 < \lambda < 1.$$

[16]Since the relative price of imports and exports is constant in our model our results would be the same if we used any homogeneous of degree one function as the C_H aggregator.

The variable $\tilde{P}_t$ is the theoretical price index that corresponds to the household's utility function. This is the solution to the following problem:

$$\tilde{P}_t = \min_{C_{E,t}C_{I,t},C_{L,t},C_{NT,t}} P_{E,t}C_{E,t} + P_{I,t}C_{I,t} + P_{L,t}C_{L,t} + P_{NT,t}C_{NT,t}$$
$$\text{s.t. } (C_{L,t} + C_{H,t})^{\gamma_L}(C_{NT,t})^{1-\gamma_L-\gamma_H}C_{H,t}^{\gamma_H} = 1,$$
$$C_H = C_I^{1-\lambda}C_E^{\lambda}.$$

This utility function implies that the consumption of local goods is zero when its price becomes high relative to the price of the imported good. More precisely, $C_L = 0$ whenever $P_L > \gamma_L P_I/(\gamma_L + \gamma_H)$. So consumers prefer the imported good to the local good in the sense that when these two goods have the same price, only the former is consumed. We abstract from foreign demand for this product by assuming that transportation and distribution costs are such that the previous condition holds from foreigners' point of view.

The household's budget constraint is given by:

$$\sum_{i=E,I,L,NT} P_{i,t}C_{i,t} + S_t a_{t+1} + M_{t+1} - M_t + S_t\tau_t =$$
$$\sum_{i=E,L,NT,D} [W_t N_{it} + R_{i,t}K_i + \Pi_{i,t}] + (1+r)S_t a_t,$$
$$\lim_{t\to\infty} \frac{a_{t+1}}{(1+r)^t} = 0,$$

where τ_t denotes lump sum taxes and a_t represents the household's beginning of time t net foreign assets measured in dollars. Households can borrow and lend in international capital markets at a dollar interest rate of r. They are subject to the following borrowing constraint:

$$a_{t+1} \geq \bar{a}_{t+1},$$

where $\bar{a}_{t+1}$ is the minimum level of net foreign assets that households are allowed to hold at time $t+1$. We assume that this constraint is initially non-binding and that $\bar{a}_{t+1}$ is expected to remain constant over time.

The Government

The government can borrow and lend in the international capital market. Its intertemporal budget constraint is given by:

$$S_t f_{t+1} = S_t f_t(1+r) + S_t \tau_t + M_{t+1} - M_t - S_t g_t,$$
$$\lim_{t\to\infty} \frac{f_{t+1}}{(1+r)^t} = 0.$$

Here f_t denotes the dollar value of the government's net foreign assets at the beginning of time t. In addition, g_t denotes the real value of government spending. We assume that both taxes and government spending are exogenous.[17] The government faces a borrowing constraint that is initially non-binding:

$$f_{t+1} \geq \bar{f}_{t+1}.$$

The value of $\bar{f}_{t+1}$ is expected to remain constant over time. In addition we assume that the initial value of f_0 is:

$$f_0(1+r) = \sum_{t=0}^{\infty} \frac{g_t - \tau_t}{(1+r)^t},$$

and that the government keeps the money supply constant. This implies that net foreign assets are constant over time.

Equilibrium

A perfect foresight competitive equilibrium for this economy is a set of paths for quantities $\{C_{j,t}, N_{i,t}, K_i, Z_{l,t}, a_{t+1}, M_{t+1}, X_{j,t}, \tau_t, g_t, Y_{i,t}, \Pi_{i,t}, a_t, f_t\}$ and prices $\{S_t,$

[17] This formulation has two implicit assumptions: (i) government spending is denominated in importable/exportables; and (ii) there are no distribution costs associated with government purchases. Since we treat government expenditures as exogenous the first assumption does not have a significant impact on our analysis. The second assumption accords with evidence provided in Burstein, Neves and Rebelo (2001).

$W_t, R_{i,t}, \bar{P}_{l,t}, \bar{P}_{Z,t}, P_{j,t}\}$ where $h \in \{E, I, L\}$, $i \in \{E, L, NT, D\}$, $j \in \{E, I, L, NT\}$, $l \in \{E, L, NT\}$ such that (i) $C_{j,t}, a_{t+1}, M_{t+1}$ solve the household's problem given the path for prices and profits; (ii) $N_{i,t}, K_{i,t}, Z_{l,t}$ solve firms' maximization problem given goods and factors of production prices; (iii) the government's intertemporal budget constraint holds; (iv) the goods, labor, money and exchange rate markets clear.

Our Experiment

At time zero there is an unanticipated tightening of the external borrowing constraint both for private agents and the government (i.e. an increase in $\bar{a}_{t+1}$ and $\bar{f}_{t+1}$) so that the new borrowing constraints are binding. This shock is in the spirit of the sudden stops in international credit flows discussed by Calvo (1998), Christiano, Gust and Roldos (2000) and Mendoza (2000).

Since government spending and taxes are exogenous, the fact that the new government borrowing constraint binds means that the government is forced to print money, thus creating a devaluation. At the same time, the shock to private agents' borrowing constraint implies that their consumption must fall. We choose the shocks to $\bar{f}_{t+1}$ and $\bar{a}_{t+1}$ so that: (i) the government is forced to print an amount of money that results in the exchange rate devaluation that we observe in the data; and (ii) the change in nominal consumption expenditures coincides with what we observe in the data. It follows that the size of the shock depends on the particular parameterization of the model.

The Basic Forces at Work in the Model

Before discussing our quantitative results it is useful to describe the key mechanisms at work in our model. The shock to the household's borrowing constraint (i.e. the rise in $\bar{a}_{t+1}$) forces the economy to increase its current account surplus (or reduce its current account deficit). In principle there are many ways in which this could be accomplished. Given our assumptions about preferences it is optimal for private agents to reduce the consumption of nontraded goods and imported goods, while increasing the consumption of local, inferior goods. Agents use the resources freed from the production of nontradable goods to increase the production of exported goods. Given our assumptions about technology and intersectoral immobility of capital the marginal real cost of producing nontradable goods is increasing in output. Other things equal, the fall in the production of nontradable goods induces a decline in their dollar price. This mitigates the rise in the domestic price of nontradable goods. At the same time the presence of distribution costs and 'flight from quality' mutes the rise in the domestic price of tradable goods. The question we turn now to is whether these forces are quantitatively powerful enough to account for observed inflation without generating other counterfactual implications.

Calibration: The Korean Case

We used information from the Korean 1995 input-output matrix (Bank of Korea (1998), table 13) to calibrate θ_E, θ_L and θ_{NT} so that the initial steady state shares of imported materials in total output excluding distribution in the exports, local, and nontradable goods sectors are 18, 18 and 4 percent, respectively. The first two values are consistent with the share of imported materials in total manufacturing output. The third value is the corresponding number for the service sector. We set the values of ϕ_E, ϕ_I and ϕ_L so that the initial steady state distribution margins are 50 percent.[18] We assume that α is equal to 0.55, the

[18] Burstein, Neves and Rebelo (2001) estimate that the US distribution margin is 42 percent. We obtained an estimate of roughly 50 percent for Korea by adjusting the US distribution margin for the difference in labor productivity in the retail sector reported in Baily and Solow (2001).

share of labor in 1996 Korean national income.[19]

We choose γ_L, γ_H and λ so that the initial steady state of our model matches the following features of the pre-crisis Korean data: (i) the share of nontradables in consumption expenditures in the Korean 1997 CPI basket (0.52); (ii) the share of imported consumption goods (excluding distribution costs) in total consumption expenditures in the 1996 Korean national income accounts (7.5 percent); and (iii) the share of domestically consumed export goods in total consumption expenditures, estimated using the 1993 Korean input-output matrix (0.15).[20] Given these assumptions, the steady state shares of C_E, C_I, C_L, and C_{NT} in total consumption expenditures are equal to 0.15, 0.15, 0.18 and 0.52, respectively.

We normalize the total labor force to one, and choose $A_E$so that the sum of employment in the exportable and local goods sectors is equal to 0.26. This figure corresponds to the share of industrial employment in total non-farm employment for Korea in 1996 according to OECD data. We normalized the foreign prices of materials, imports, and exports in the initial steady state as follows: $\bar{P}_Z^* = 1$, $\bar{P}_I^* = 1 + \theta_I$, $\bar{P}_E^* = \bar{P}_I^* = 1 + \theta_E$. The productivity level parameters, A_L, A_{NT} and A_D, are chosen so that, exclusive of material costs, the initial producer price of nontradable goods, exports goods and the initial price of retail services (P_0^D) are the same, and $P_0^L = 0.7 P_0^I$. Unfortunately, there is very little information about this ratio. Our decision to set it to 0.7 before the devaluation was motivated by a market research study recently conducted by AC Nielsen (2001b) for Argentina.

Finally, it is easy to show that, given the way we calibrate the shocks to the

[19] According to our estimates labor share is similar in the tradables and nontradables sector (0.54 versus 0.57). Young (1995) reports a higher economy-wide labor share (0.70 for the period 1966-1990). In part this higher estimate reflects the fact that he includes self-employed income.

[20] To calculate this share we proceeded as follows. For each sector we computed the ratio of exports to total sectoral output. Sectors for which this ratio was greater than 20 percent were classified as export sectors. We then computed the value of domestic consumption in these sectors as a fraction of total consumption expenditures.

economy, the values of the remaining parameters (β, r, σ, g, τ) do not affect the results that we report. Hence we do not specify their values.

We choose the shock to $\bar{a}_{t+1}$ and $\bar{f}_{t+1}$ so that, consistent with the data, the exchange rate depreciates by 41.2 percent and nominal consumption expenditures fall by 4.65 percent in the first year after the shock. The implied change in $\bar{a}_{t+1} + \bar{f}_{t+1}$ depends on the exact version of the model being analyzed. In the version of the model with distribution costs and local goods, net foreign assets must rise by 11.7 percent.[21] Finally, we assume that the dollar price of foreign imports and exports fall by 3 percent in the first year after the shock. This corresponds to the percentage change in the U.S. producer price index between September 1997 and September 1998.

The baseline Korean parameter values are summarized in table 5. While we view our baseline parameterization as a plausible benchmark, there is substantial uncertainty about some individual parameter values. For this reason we ran numerous experiments to test the sensitivity of the model. While we only report a subset of this information to conserve on space, in all of our results, the model with distribution and local goods performs substantially better than the basic tradable/nontradable goods model.

Results for Korea

Table 6 shows the price implications of the model for the Korean case. Consider first the standard two-sector tradable-nontradable model. A number of interesting results emerge here. First, inflation in the model is much higher than actual inflation (23.7 percent versus 6.6 percent). Second, the model is consistent with the decline in the relative retail price of nontradable goods. But it overstates

[21] The statistics that we report depend only on the sum of $\bar{a}_{t+1}$ and $\bar{f}_{t+1}$ and not on their individual values.

the extent of this decline: the price of nontradables relative to the retail price of tradables falls by roughly 3 percent in the data, while in the model it declines by 30 percent. Third, the model substantially overstates the increase in the retail price of imports and exports relative to the data (38.2 versus 25.4). In addition, since PPP holds for tradable goods, the model counterfactually implies that the change in the retail price of imports and tradable goods is the same.

Adding a distribution sector substantially improves the performance of the model: now the implied rate of inflation is 12.9 percent and the price of nontradables relative to the retail price of tradables falls by only 12.2 percent. In addition, the rise in the price of imports is reasonably close to that suggested by the Runzheimer apparel index (19 versus 25.4). However, by construction, inflation in the retail price of imports and tradable goods is still the same.

The impact of local goods on the model's performance depends on the method that is used to measure CPI. With the 'fixed brand' method there is only a marginal improvement in the model's implications. But, at least qualitatively, the model is now consistent with the fact that the retail price of imports and exports rises by more than the retail price of tradable goods.

The improvement in the model's performance is more noticeable once we move to the 'variable brand' methods. This is because the expenditure share of local goods rises after the shock while the retail price of local goods rises by much less than the retail price of importables. In the most extreme case ('variable brand' 3) the model has no difficulty at all in explaining low rates of change in the price of tradables, nontradables and the CPI. Indeed, the model implies that measured inflation should have been *negative* and the measured price of tradable goods should have fallen. Even with the least extreme method, 'variable brand' 2, the performance of the model improves noticeably relative to the model without local goods. Finally, in the intermediate case, 'variable brand' 1, overall inflation in the model is 9.0 percent. The retail price of nontradables decreases only by 7 percent and the retail price of imports rises by 6.8 percentage points more than the price of tradable goods.

Based on these results we conclude that with local goods and 'flight from quality' the model does a good job of accounting for Korea's post-crisis inflation experience. Table 7 summarizes the model's output implications. Several results are worth noting. First, consistent with the data, exports $(Y_{E,t} - C_{E,t})$ rise and imports fall after the devaluation. However, the model greatly overstates the boom in exports. Second, the model is consistent with the decline in output of the nontradable sector.[22] But the size of the decline is large relative to the data. Third, the model is consistent with the fact that real GDP declines. However the decline is small relative to the data. Fourth, the model counterfactually predicts a large boom in the output of the tradable good sector.

The model's shortcomings with respect to output reflect its stark nature which abstracts from credit market frictions. Various authors, including Aghion, Bacchetta and Banerjee (2000), Caballero and Krishnamurthy (2001), Christiano, Gust, and Roldos (2000), and Schneider and Tornell (2000), have argued that in many countries large devaluations are associated with production disruptions arising from credit market frictions. We assess the implications of such disruptions for inflation and sectoral reallocation by mimicking them in a reduced form way. Specifically we suppose that a large devaluation is associated with a fall in total factor productivity in the export sector. The size of the decline is calibrated so that the model generates a decline in exports equal to that observed in the data. This requires a large decline in total factor productivity of 21.1 percent. Table 6 reveals that the local goods version of the model now does an even better job

[22] Output in this sector is defined as the sum of nontradable goods production and value added in distribution evaluated at constant prices.

of accounting for inflation. Under 'variable brand' 1, the implied rate of inflation is now 4.1 percent, which slightly understates the observed rate of inflation. As before both the price of nontradables and tradables falls, with the relative price of nontradables declining by 8.2 percent. We conclude that allowing for production disruptions does not overturn the model's implications for inflation.

Finally, this version of the model does substantially better with respect to quantities. First, the decline in output of the nontradable sector is now closer to that observed in the data (-8.2 versus -4.9 percent). Second, the decline in real GDP is quite close to that observed in the data (-5.1 versus -5.8 percent). Third, the boom in the tradable goods sector is greatly mitigated, with output in that sector now rising only by 2.7 percent.

Calibration: The Mexican Case

We set the values of ϕ_E, ϕ_I and ϕ_L so that the initial steady state distribution margins are 50 percent.[23] We used Mexico's 1990 input-output matrix (Ten Kate et. al. (1993)) to calibrate θ_E, θ_L and θ_{NT}. We chose these parameters so that the initial steady state shares of imported materials in total output of the export, local, and nontradable sectors are 10.3, 10.3 and 2.3 percent, respectively. The first two values are consistent with the share of imported materials in the total output of the economy excluding the service sector. The third value is the corresponding number for the service sector. We assume that α is equal to 0.40, the share of labor in 1994 Mexican national income. We choose γ_L, γ_H and λ so that the initial steady state of our model matches: (i) the share of nontradables in consumption expenditures in the latest revision of the Mexican CPI basket (0.46); (ii) the share of imported consumption goods (excluding distribution costs) in

[23] The total distribution margin (including wholesale and retail) estimated by the 1999 Mexican 'Censo Comercial' is 70 percent. We adopted a more conservative estimate since not all goods go through wholesale and retail distribution channels.

total consumption expenditures in the 1994 Mexican national income accounts (3.6 percent); and (iii) the share of domestically consumed export goods in total consumption expenditures, estimated using the 1990 Mexican input-output matrix (0.25).[24] Given these assumptions, the steady state shares of C_E, C_I, C_L, and C_{NT} in total consumption expenditures are equal to 0.25, 0.07, 0.22 and 0.46, respectively.

We normalize the total labor force to one, and choose A_E so that the sum of employment in the exportable and local goods sectors is 0.24.[25] We normalized the foreign prices of materials, imports, and exports in the initial steady state to the same values used in the Korea calibration. The productivity level parameters, A_L, A_{NT} and A_D, are chosen so that, exclusive of material costs, the initial producer price of nontradable goods, exports goods and the initial price of retail services (P_0^D) are the same, and $P_0^L = 0.7P_0^I$. This assumption is based on an AC Nielsen (1996) study that finds that in Mexico the price of generic brands is 30 percent lower than that of branded goods. The baseline Mexican parameter values are summarized in table 5.

We choose the shock to $\bar{a}_{t+1}$ and $\bar{f}_{t+1}$ so that, consistent with the data, in the first year after the shock, the exchange rate depreciates by 80.0 percent and nominal consumption expenditures rises by 20.6 percent. The implied change in $\bar{a}_{t+1} + \bar{f}_{t+1}$ depends on the exact version of the model being analyzed. In the version of the model with distribution costs and local goods, net foreign assets must rise by 12.5 percent. Finally, we assume that the dollar prices of foreign imports and exports increase by 3.2 percent in the first year after the shock. This corresponds to the percentage change in the U.S. producer price index between

[24] This share was computed with the same method used for Korea and a 10 percent threshold value to define export sectors. Using a 20 percent threshold, as we did for Korea, would leave us with only two export industries: mining and metal products.

[25] This corresponds to urban employment in Agriculture, Mining, and Manufacturing in 1994 according to the Encuesta Nacional de Empleo Urbano.

November 1994 and November 1995.

Results for Mexico

Table 6 shows the price implications of the model for the Mexican case. Consider first the standard two-sector tradable-nontradable model. The main results are as follows. First, as in the Korean case, inflation in the model is much higher than actual inflation (62.7 percent versus 39.5 percent). Second, the model generates a decline in the price of nontradable goods relative to the retail price of tradable goods. But, as in the Korean case, it overstates the extent of this decline (14 percent in the data versus 50.9 percent in the model). Third, the model substantially overstates the increase in the retail price of imports relative to the data (83.3 versus 37.6).

Once we allow for a distribution sector the model reproduces the 40 percent observed rate of inflation. In addition the model comes very close to matching the rate of change in the price of tradables and nontradables. Therefore the model accounts for the decline in the price of nontradables goods relative to the retail price of tradable goods. The one shortcoming of the model with respect to prices is that it overstates the rise in the retail price of imports, which is 37.6 percent in the data and 49.5 percent in the model.

The version of the model with local goods and the 'fixed brand' method for measuring the CPI behaves very similarly to the model without local goods. Introducing the 'variable brand' methods leads to a deterioration of the model's performance with the extent of the deterioration depending on the precise method use. Taken together these results are consistent with our prior that the Mexican method for computing the CPI is well described by the 'fixed brand' method.

Table 7 indicates that the shortcomings of the model with respect to quantities are similar in the Korean and the Mexican cases. So, as in the Korean case, we assess the implications of credit disruptions for inflation and sectoral reallocation by allowing for a fall in total factor productivity in the export sector. The size of the decline is calibrated so that the model generates a decline in exports equal to that observed in the data. This requires an enormous decline in total factor productivity: 50.3 percent. Table 6 shows that the price implications of the model are robust to allowing for this shock. Note that this version of the model does much better with respect to quantities. First, the decline in output of the nontradable sector is now closer to that observed in the data (-6.9 versus -7.9 percent). Second, the decline in real GDP is quite close to that observed in the data (-7.4 versus -6.4). Finally, the model predicts a decline in the output of the tradable sector that is similar to that observed in the data (-9.0 versus -4.4). This is true despite the fact that the model is consistent with the observed boom in exports.

5. Conclusions

This paper studies the behavior of inflation and real exchange rates after large devaluations associated with significant declines in the growth rate of aggregate income. After documenting the behavior of prices in these types of episodes, we argued that distribution costs and 'flight from quality' in consumption can account quantitatively for the key facts about the behavior of prices. We make this argument in the context of a general equilibrium model that abstracts entirely from sticky prices.

Our benchmark model overstates the boom in the export sector as well as the reallocation of production from the nontradables to the tradables sector. This is not surprising given that the model abstracts from production disruptions arising from credit market frictions in the aftermath of large devaluations. We assess the implications of such disruptions for inflation and sectoral reallocation by mimicking them in a reduced form way. Specifically, we allowed for a fall in total factor productivity in the export sector. Two main conclusion emerge from this part of our analysis. First, the price implications of the benchmark model are robust to this perturbation. Second, this perturbation greatly improved the model's shortcomings regarding its implications for exports and sectoral flows. This suggests that formally integrating credit market frictions into our benchmark model is likely to be a fruitful avenue for further research.

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TABLE 1

Cumulative Logarithmic Percentage Changes in the First Two Years After Devaluation

COUNTRY	Korea		Thailand		Malaysia		Philippines		Indonesia	
	Sept. 98	Sept. 99	June 98	June 99	July 98	July 99	June 98	June99	June 98	June99
Dollar Exchange Rate	41.2	27.6	49.7	35.9	48.2	39.1	42.6	36.2	171.1	108.3
Effective Exchange Rate	32.5	25.1	33.9	26.3	32.2	29.4	30.1	28.8	155.3	99.0
CPI Inflation	6.6	7.4	10.1	9.0	5.7	8.1	10.1	15.7	44.9	66.8
Price of Tradables	8.2	10.2	12.5	9.8	6.0	8.7	9.0	13.6	n.a	n.a.
Price of Non-Tradables	5.1	4.8	9.3	9.7	5.4	7.5	10.1	18.6	n.a	n.a.
Import Price Index	16.5	10.4	40.4	20.4	n.a.	n.a.	26.2	25.9	93.2	93.0
Export Price Index	22.6	16.0	32.3	17.6	n.a.	n.a.	43.1	46.3	137.2	96.9
Wholesale Price Index	10.8	9.7	19.1	10.4	15.7	8.7	12.6	16.5	83.9	85.9
Runzheimer Tradable Price Index	27.2	32.8	16.0	15.0	13.1	17.5	19.6	21.3	59.9	87.0
Runzheimer Apparel Price Index	25.4	36.9	14.1	14.4	13.2	15.9	44.3	40.9	100.3	120.3
CPI Apparel Price Index	2.8	5.0	6.4	6.4	0.3	-2.1	8.1	13.0	n.a.	n.a.
Public Goods Price Index	7.5	9.5	10.0	9.1	3.6	5.3	n.a.	n.a.	n.a.	n.a.

COUNTRY	Mexico		Brazil		Finland		Sweden	
Period	Nov. 95	Nov. 96	Dec. 99	Dec. 00	Aug. 93	Aug. 94	Sept. 93	Sept. 94
Dollar Exchange Rate	80.0	83.3	42.4	48.7	38.2	25.6	40.2	34.0
Effective Exchange Rate	80.1	82.7	39.0	40.2	17.2	10.2	26.7	25.1
CPI Inflation	39.5	64.0	8.7	15.4	2.0	3.9	4.1	6.6
Price of Tradables	45.6	72.1	11.0	n.a.	n.a.	n.a.	3.7	6.4
Price of Non-Tradables	31.6	53.6	6.5	n.a.	n.a.	n.a.	6.0	9.6
Import Price Index	70.6	74.1	39.6	38.5	13.0	12.6	16.3	20.7
Export Price Index	61.7	79.2	32.1	42.8	6.3	8.6	11.1	17.1
Wholesale Price Index	43.3	68.3	25.4	36.8	3.9	6.3	8.7	12.4
Runzheimer Tradable Price Index	49.5	64.2	8.8	n.a.	n.a.	n.a.	n.a.	n.a.
Runzheimer Apparel Price Index	37.6	49.4	13.7	n.a.	n.a.	n.a.	n.a.	n.a.
CPI Apparel Price Index	37.6	62.8	3.4	n.a.	n.a.	n.a.	n.a.	n.a.
Public Goods Price Index	29.1	52.7	8.1	n.a.	n.a.	n.a.	n.a.	n.a.

TABLE 2: Aggregate Economic Variables

Cumulative Logarithmic Percentage Changes in the First Two Years After Devaluation

	Korea			**Thailand**		
	1997	1998	1999	1997	1998	1999
Real Consumption	0.00	-12.31	-2.35	0.00	-12.20	-8.30
Real GDP	0.00	-6.92	3.42	0.00	-10.74	-7.51
Nominal Trade Balance (TB/GDP)	-1.02	13.46	6.86	0.01	0.16	0.13
Real Exports	0.00	12.44	27.58	0.00	6.34	15.80
Real Imports	0.00	-25.36	0.06	0.00	-24.42	-14.32
	Malaysia			**Philippines**		
	1997	1998	1999	1997	1998	1999
Real Consumption	0.00	-10.80	-7.57	0.00	3.39	6.00
Real GDP	0.00	-7.65	-2.05	0.00	-0.54	2.75
Nominal Trade Balance (TB/GDP)	0.93	21.80	24.77	-10.34	-6.60	1.02
Real Exports	0.00	0.49	13.04	0.00	-23.62	-20.04
Real Imports	0.00	-20.77	-10.49	0.00	-15.91	-18.74
	Indonesia					
	1997	1998	1999			
Real Consumption	0.00	-3.38	-1.91			
Real GDP	0.00	-14.05	-13.24			
Nominal Trade Balance (TB/GDP)	-0.28	9.75	8.01			
Real Exports	0.00	10.60	-28.06			
Real Imports	0.00	-5.43	-58.02			
	Mexico			**Brazil**		
	1994	1995	1996	1998	1999	2000
Real Consumption	0.00	-10.00	-7.80	n.a.	n.a.	n.a.
Real GDP	0.00	-6.37	-1.34	0.00	0.73	5.13
Nominal Trade Balance (TB/GDP)	-4.83	2.66	2.11	-2.02	-1.11	n.a.
Real Exports	0.00	26.39	43.13	0.00	-0.87	5.91
Real Imports	0.00	-16.30	4.31	0.00	-7.91	0.00
	Finland			**Sweden**		
	1992	1993	1994	1992	1993	1994
Real Consumption	0.00	-2.95	-1.06	0.00	-3.11	-1.34
Real GDP	0.00	-2.63	-0.82	0.00	-3.30	-2.03
Nominal Trade Balance (TB/GDP)	-0.04	3.00	6.31	1.39	2.26	5.04
Real Exports	0.00	15.45	27.92	0.00	7.36	20.43
Real Imports	0.00	0.75	12.79	0.00	-2.53	9.82

TABLE 3: Price Accounting

Cumulative Logarithmic Percentage Changes in the First Two Years After Devaluation

COUNTRY	Korea		Thailand		Malaysia		Philippines		Mexico		Brazil	
	Sept. 98	Sept. 99	June 98	June 99	July 98	July 99	June 98	June99	Nov. 95	Nov. 96	Dec. 99	Dec. 00
DATA												
Exchange rate depreciation	41.2	27.6	49.7	35.9	48.2	39.1	42.6	36.2	80.0	83.3	42.4	48.7
PPI US	-3.0	0.4	-1.9	-1.6	-1.6	-1.0	-1.9	-1.6	3.2	5.3	4.1	10.1
CPI Inflation	6.6	7.4	10.1	8.9	5.7	8.1	10.1	15.7	39.5	64.0	8.7	15.4
ACCOUNTING												
PPP	38.2	28.0	47.7	34.3	46.6	38.2	40.7	34.7	83.1	88.6	46.5	58.8
1) Add Non-tradables	22.3	16.6	30.3	22.7	30.8	26.0	31.9	29.8	62.4	73.8	28.8	n.a.
2) Add Distribution	14.1	10.8	20.3	16.4	18.9	17.2	21.6	24.4	48.2	64.2	17.8	n.a.
Add Local goods												
3) Fixed brands	11.3	9.0	16.9	14.3	14.8	14.2	18.1	22.6	43.2	61.0	14.1	n.a.
4) Variable Brands 1	8.7	6.7	14.1	11.9	11.5	11.3	14.6	19.7	39.7	58.1	11.0	n.a.
5) Variable Brands 2	10.3	8.3	15.7	13.6	13.3	13.1	16.8	21.9	41.3	59.8	12.7	n.a.
6) Variable Brands 3	-10.4	-10.8	-7.0	-6.6	-13.2	-11.1	-12.7	-4.2	14.1	36.1	-11.4	n.a.
Share of Non-Tradables in CPI	0.52		0.50		0.43		0.32		0.46		0.48	

TABLE 4: Sensitivity Analysis

Cumulative Percentage Changes

Price Accounting, CPIU Korea, Variable Brands 3

		New Share of Local Goods				
		40	50	60	70	80
	1	10.6	9.7	8.8	7.9	7.0
	0.9	10.8	9.4	8.0	6.5	5.1
$P_{L,0}/P_{I,0}$	0.8	11.1	9.1	7.1	5.0	3.0
	0.7	11.3	8.7	6.1	3.4	0.6
	0.6	11.6	8.4	5.0	1.5	-2.0
	0.5	11.9	7.9	3.8	-0.5	-5.0

TABLE 5: Model Parameters

	KOREA	**MEXICO**
α	0.55	0.40
ϕ_E	1.22	1.11
ϕ_I	1.22	1.11
ϕ_L	0.85	0.78
θ_E	0.22	0.11
θ_L	0.15	0.08
θ_{NT}	0.04	0.03
N	1.00	1.00
A_D	4.37	0.41
A_E	3.90	0.27
A_L	3.67	0.32
A_{NT}	6.08	0.56
γ_L	0.39	0.44
γ_{NT}	0.52	0.46
λ	0.50	0.78

TABLE 6: Model Results, Prices

KOREA	CPI	P_{NT}	P_T	P_I
DATA (one year after devaluation)	6.60	5.10	8.20	25.40
MODELS				
Benchmark model				
Tradables / Nontradables	23.68	8.18	38.16	38.16
Add Distribution	12.86	6.83	19.02	19.02
Add Local				
Fixed Brands	11.14	5.57	16.85	19.35
Variable Brands 1	8.96	5.57	12.52	19.35
Variable Brands 2	10.63	5.57	15.85	19.35
Variable Brands 3	-7.96	5.57	-25.07	19.35
With credit frictions				
Tradables / Nontradables	19.71	-0.96	38.16	38.16
Add Distribution	8.61	1.31	15.98	15.98
Add Local				
Fixed Brands	6.75	0.06	13.54	16.58
Variable Brands 1	4.07	0.06	8.26	16.58
Variable Brands 2	6.03	0.06	12.13	16.58
Variable Brands 3	-13.14	0.06	-29.76	16.58

MEXICO	CPI	P_{NT}	P_T	P_I
DATA (one year after devaluation)	39.50	31.60	45.60	37.60
MODELS				
Benchmark model				
Tradables / Nontradables	62.74	32.34	83.25	83.25
Add Distribution	40.79	29.77	49.46	49.46
Add Local				
Fixed Brands	38.55	28.18	46.76	51.16
Variable Brands 1	34.58	28.18	39.82	51.16
Variable Brands 2	37.21	28.18	44.44	51.16
Variable Brands 3	14.57	28.18	1.03	51.16
With credit frictions				
Tradables / Nontradables	60.33	25.17	83.25	83.25
Add Distribution	35.25	21.99	45.49	45.49
Add Local				
Fixed Brands	33.66	21.58	43.08	48.24
Variable Brands 1	28.91	21.58	34.87	48.24
Variable Brands 2	31.86	21.58	40.01	48.24
Variable Brands 3	8.46	21.58	-4.53	48.24

TABLE 7: Model Results, Quantities

KOREA	Real Output	Real Output Tradables	Real Output Non-tradables	Exports	C_I	C_L	Y_E
DATA (one year after devaluation)	-5.76	-7.30	-4.90	12.40	-51.10		
MODELS							
Benchmark model							
Tradables / Nontradables	-1.34	25.60	-12.84	95.68	-42.82	n.a.	25.60
Add Distribution	-1.86	28.71	-15.28	40.02	-23.67	n.a.	28.71
Add Local	-1.58	25.66	-13.21	54.50	-41.88	8.90	31.59
With credit frictions							
Tradables / Nontradables	-7.95	-21.15	-3.69	12.44	-42.82	n.a.	-21.15
Add Distribution	-6.00	5.78	-10.49	12.38	-20.64	n.a.	5.78
Add Local	-5.05	3.37	-8.18	12.39	-42.44	17.14	-2.66

MEXICO	Real Output	Real Output Tradables	Real Output Non-tradables	Exports	C_I	C_L	Y_E
DATA (one year after devaluation)	-6.37	-4.38	-7.85	26.39	-57.82		
MODELS							
Benchmark model							
Tradables / Nontradables	-2.04	23.61	-11.72	102.80	-62.63	n.a.	23.61
Add Distribution	-3.31	27.17	-15.25	138.47	-27.47	n.a.	27.17
Add Local	-2.65	24.06	-12.83	185.00	-57.86	14.37	30.69
With credit frictions							
Tradables / Nontradables	-8.98	-24.46	-4.55	26.42	-62.63	n.a.	-24.46
Add Distribution	-10.57	-14.05	-9.49	26.36	-24.87	n.a.	-14.05
Add Local	-7.36	-8.98	-6.85	26.38	-58.86	23.10	-41.87

Figure 1: Korea

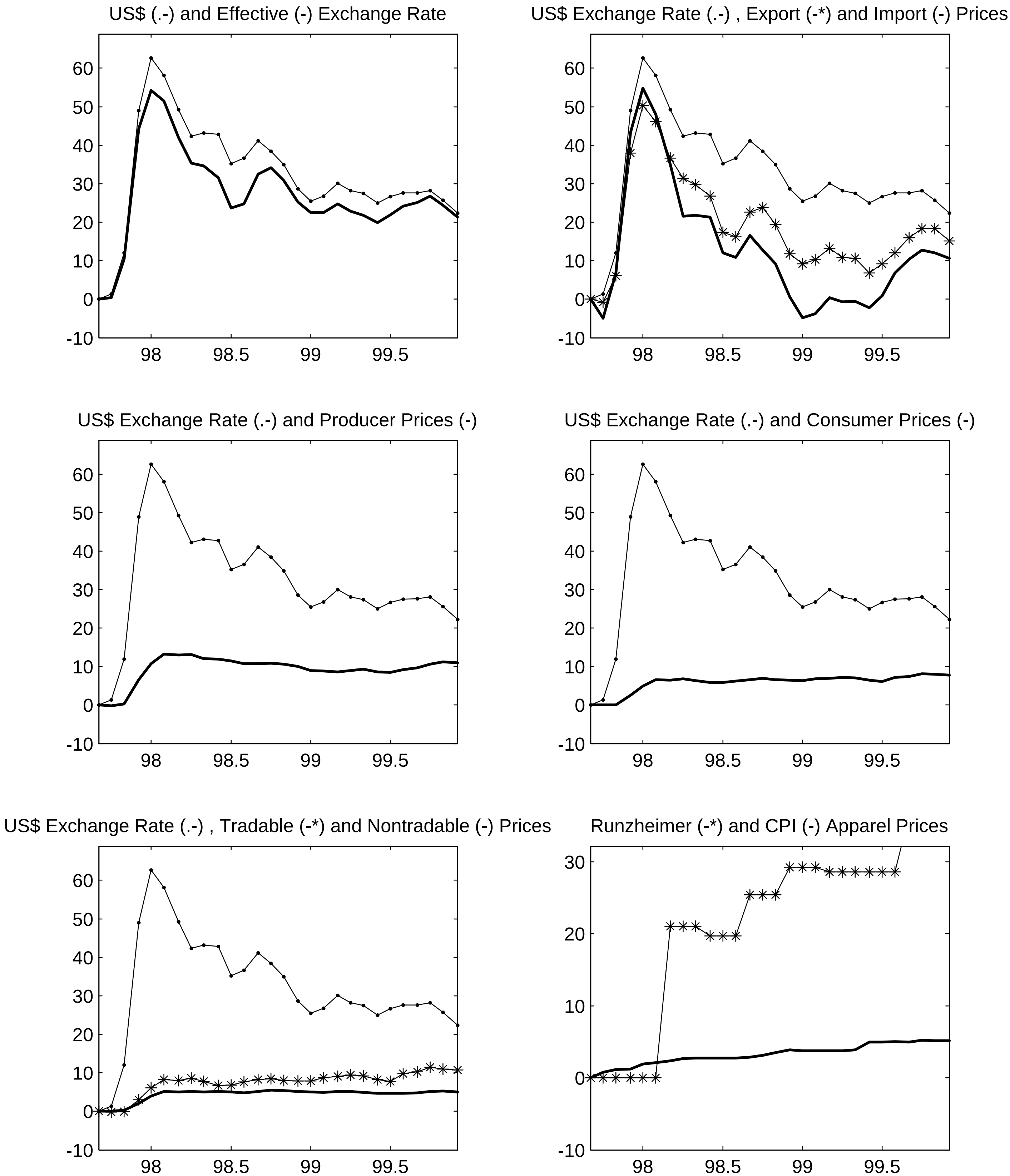

Figure 2: Thailand

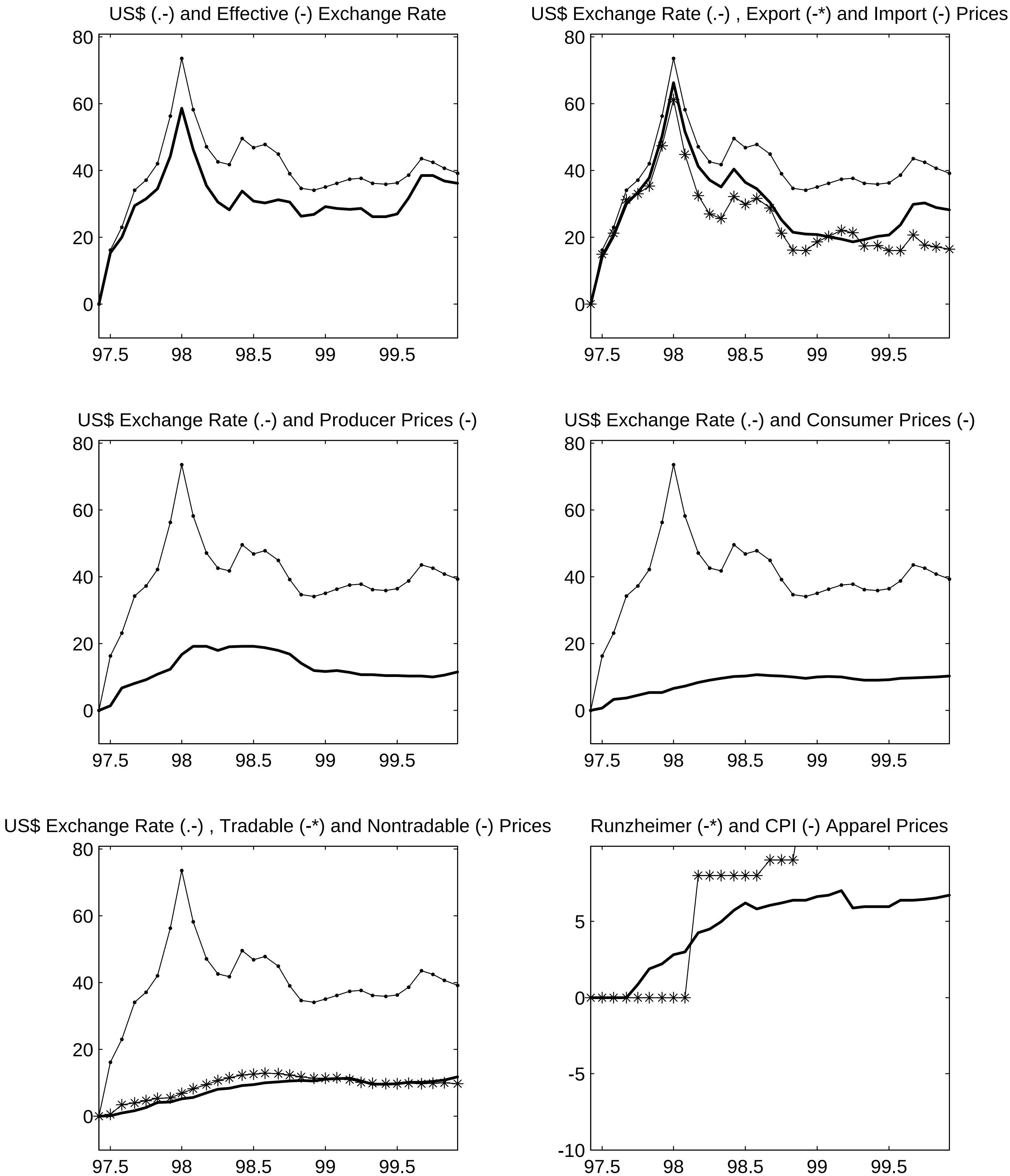

Figure 3: Malaysia

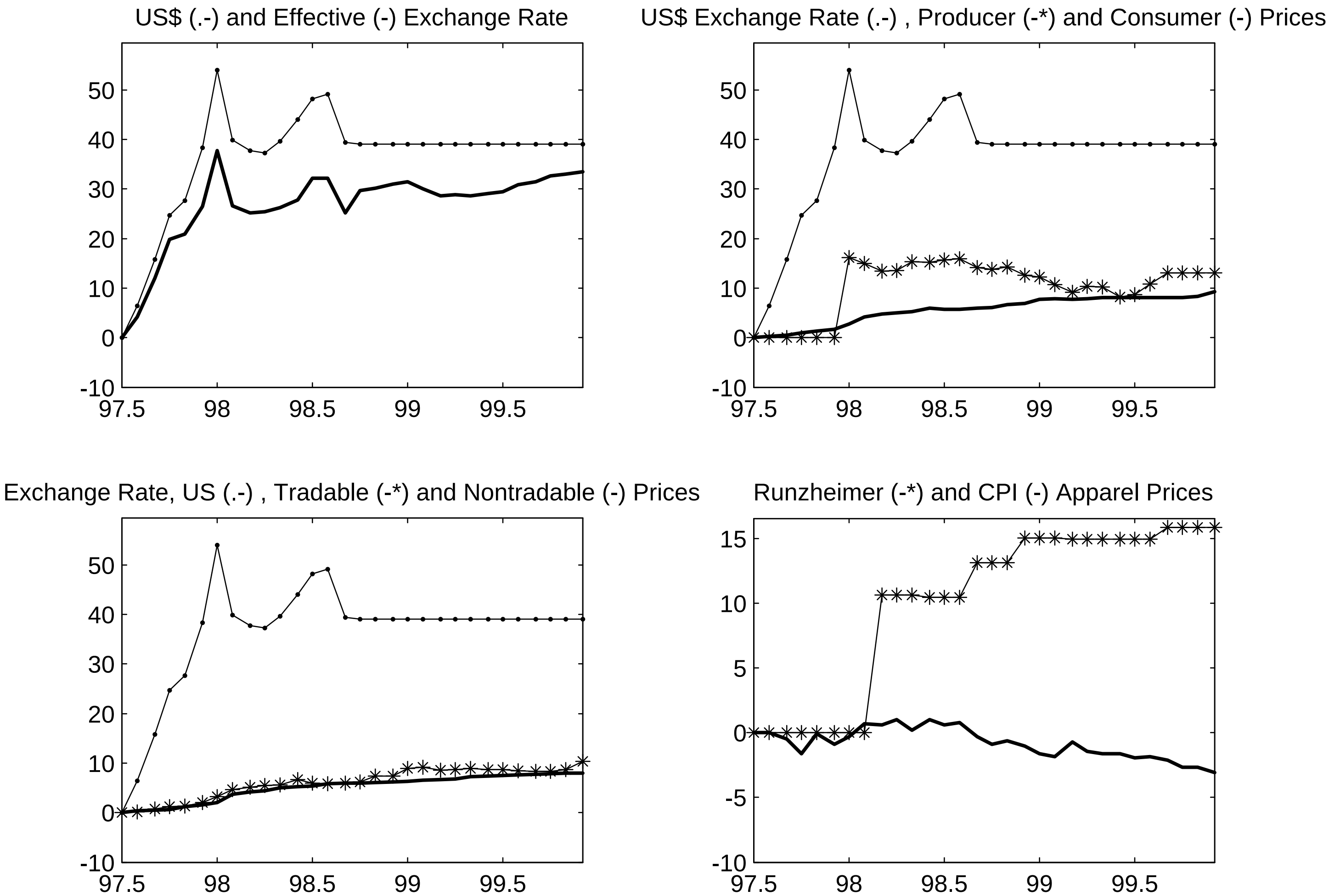

Figure 4: Philippines

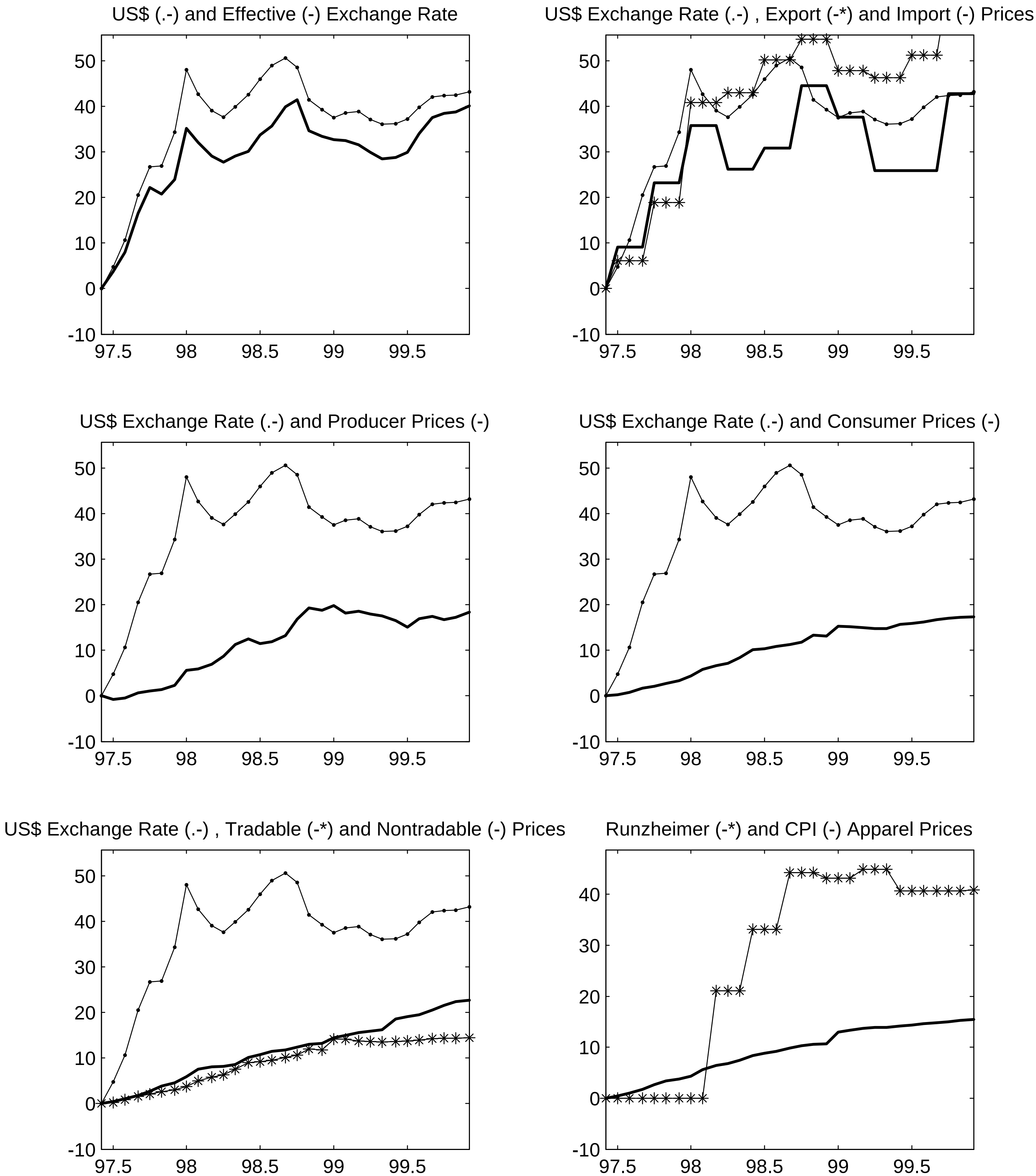

Figure 5: Indonesia

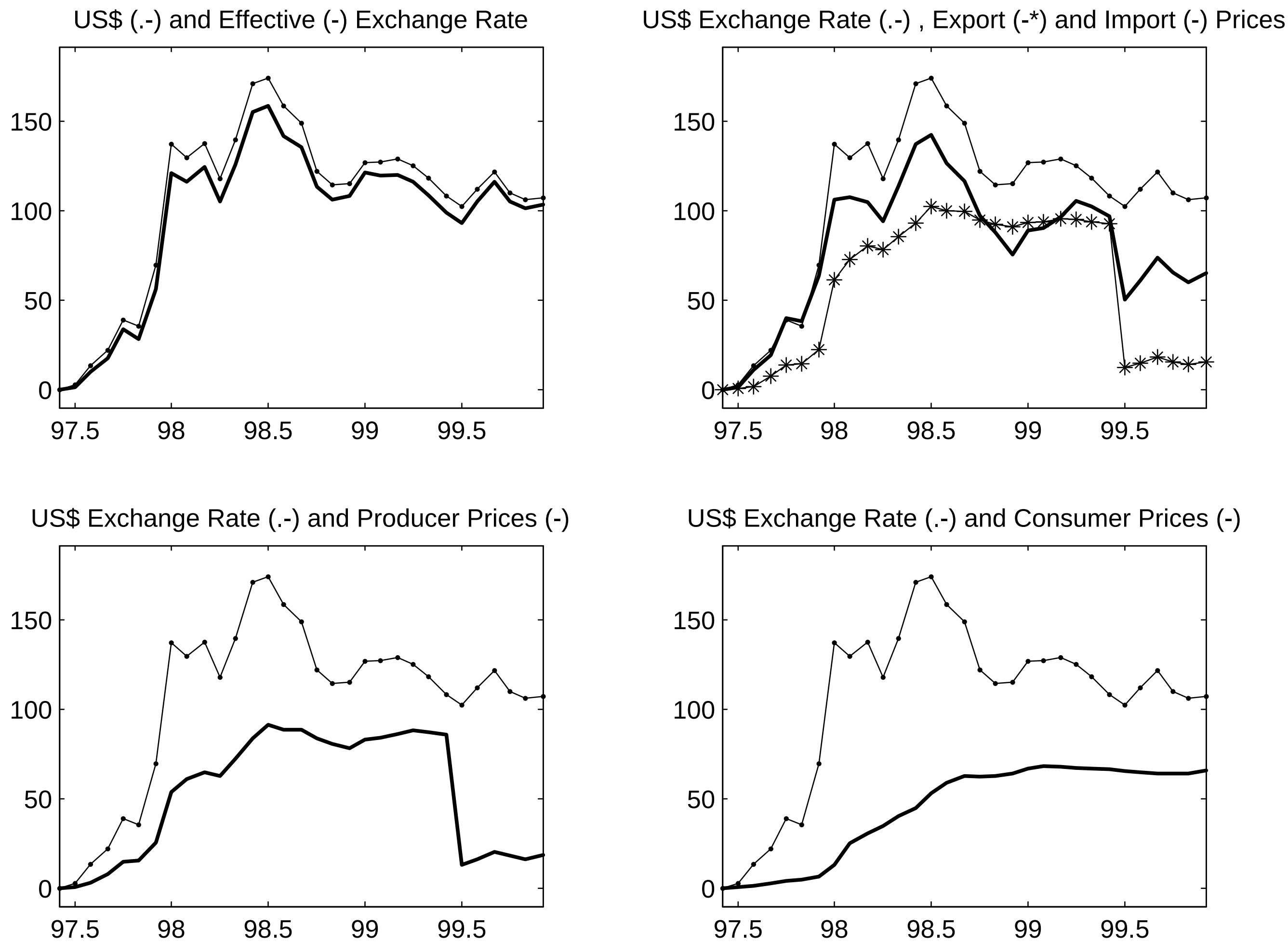

Figure 6: Mexico

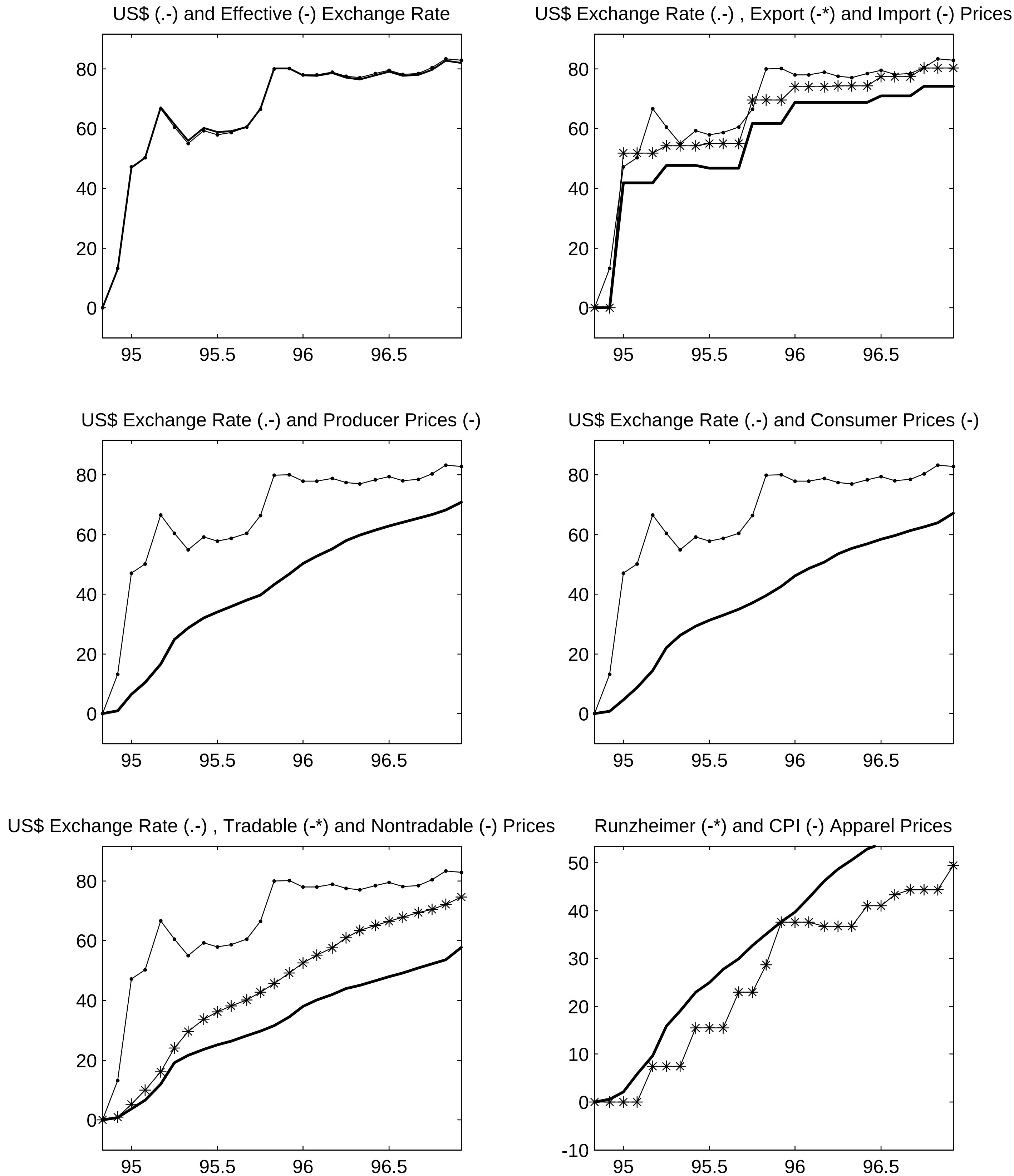

Figure 7: Brazil

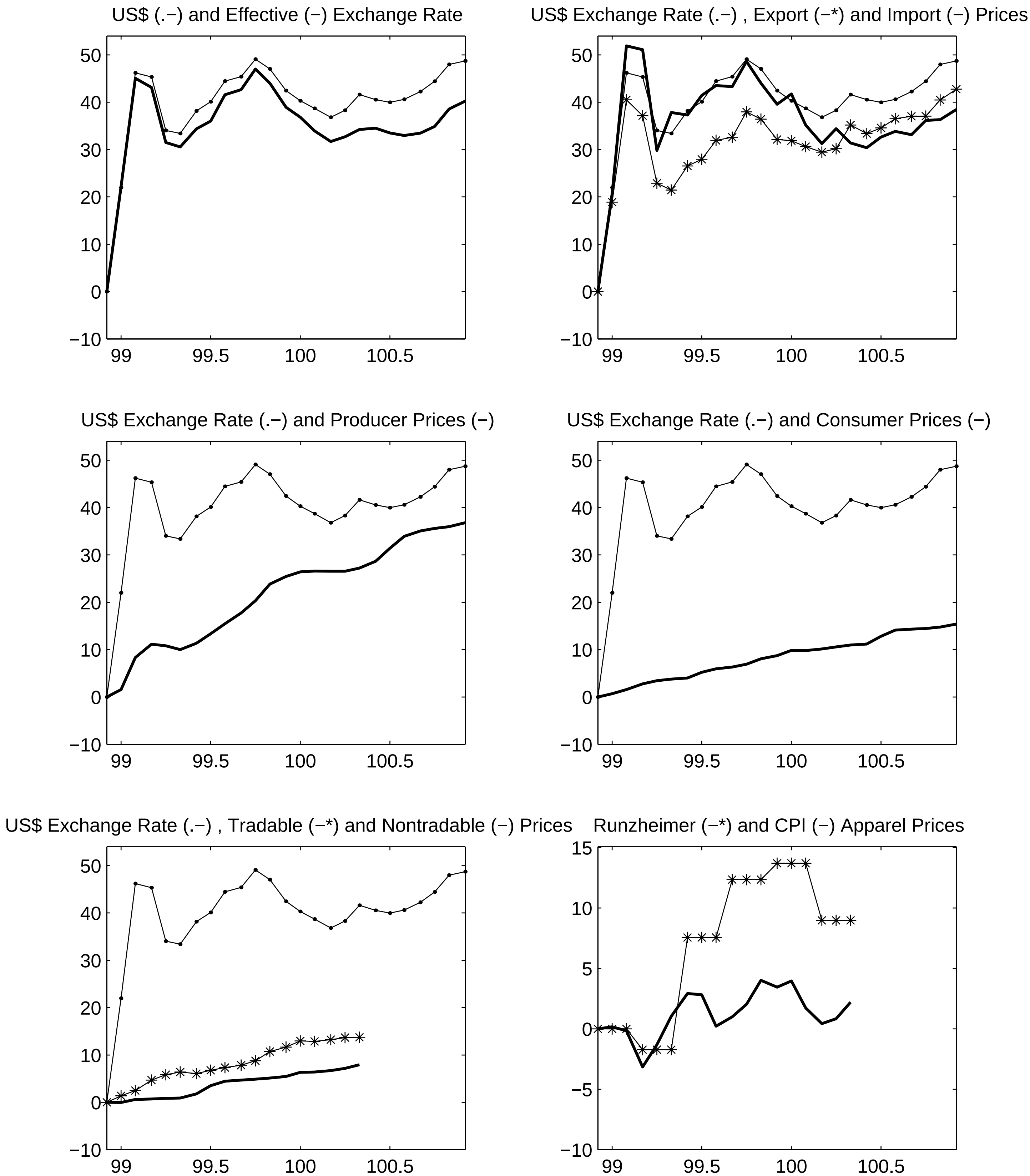

Figure 8: Sweden

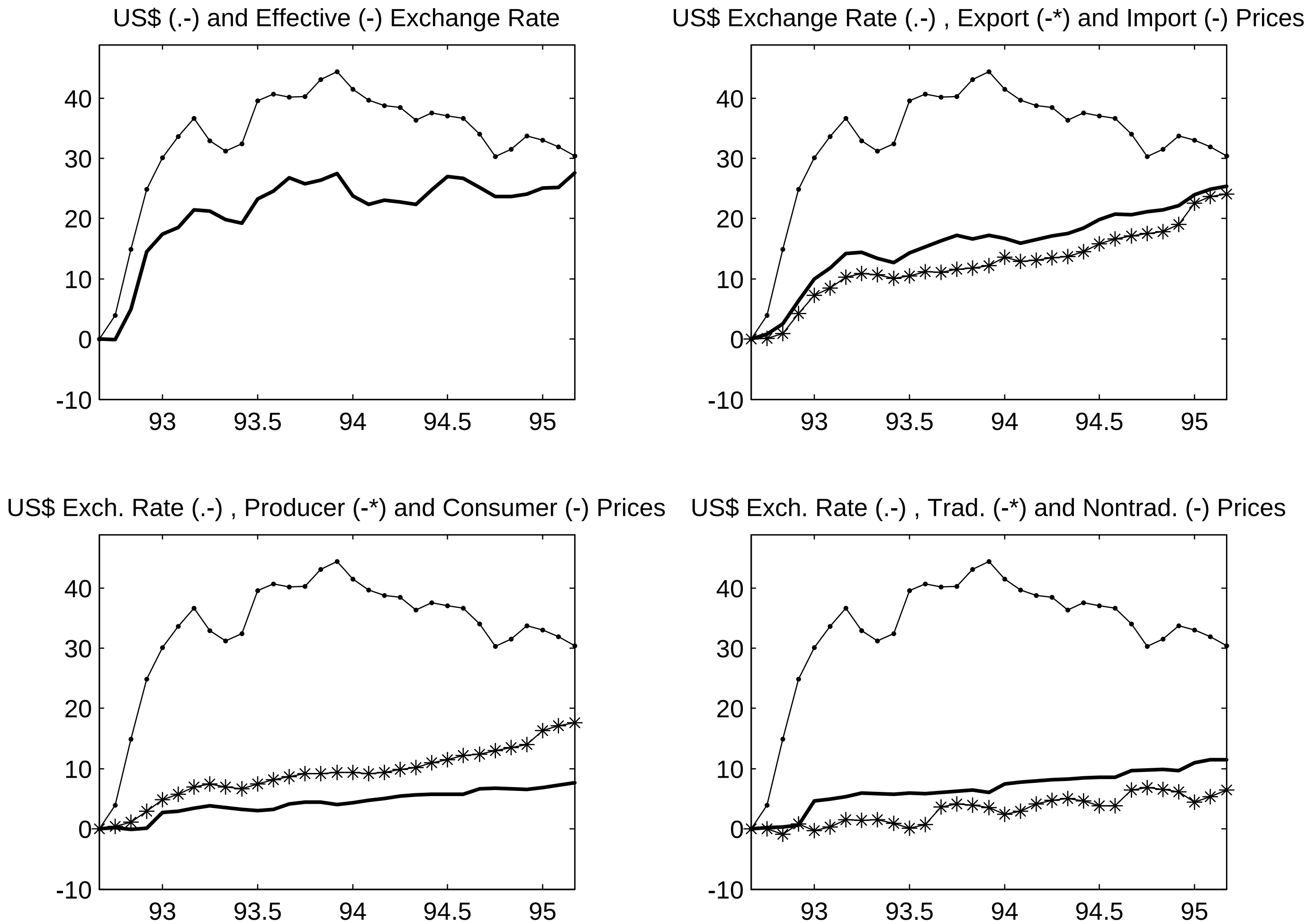

Figure 9: Finland