Large Devaluations and the Real Exchange Rate*

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Abstract

This paper argues that the primary force behind the large fall in real exchange rates that occurs after large devaluations is the slow adjustment in the price of *nontradable* goods and services. Our empirical analysis is based on data from four large devaluation episodes: Mexico (1994), Korea (1997), Brazil (1999), and Argentina (2001). We conduct a more detailed analysis of the Argentina case using disaggregated CPI data, data from our own survey of prices in Buenos Aires, and scanner data from supermarkets. We then construct an open economy general equilibrium model that can account for the slow adjustment in nontradable good prices after a large devaluation.

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1. Introduction

Large devaluations are often associated with large declines in real exchange rates (RER). In this paper we argue that the primary force inducing these declines is slow adjustment in the price of *nontradable* goods and services, not slow adjustment in the price of goods that are imported or exported. Both at short and long horizons, the rate of pass-through from exchange rates to prices is much lower for nontradable goods than for goods that are actually traded. The purpose of this paper is to document this fact and to propose an explanation.

Our empirical analysis is based on data from four large devaluation episodes: Mexico (1994), Korea (1997), Brazil (1999), and Argentina (2001). Our findings on pass-through rates can be summarized as follows. In the first three months after the onset of their currency crises, the dollar price of nontradable goods and services fell by roughly 45 percent in Korea, Brazil, and Mexico.[1] In Argentina, this price fell by a dramatic 85 percent. In sharp contrast, there were relatively small movements in the dollar price of imports measured 'at the dock', ranging from a fall of 18 percent in Argentina to a rise of 6 percent in Brazil. Even at longer horizons of one to two years, pass-through rates for nontradable goods in Korea, Brazil and Argentina are very low. While pass-through rates for Mexico at these longer horizons are larger, there is still a substantial decline in the dollar price of nontradable goods. For all four countries, the corresponding pass-through rates for import prices at the dock are substantially larger than for nontradable goods.

We complement this evidence with a more in-depth analysis of the Argentinean case using: (i) disaggregated consumer price index (CPI) data; (ii) data from our own survey of prices in Buenos Aires; and (iii) scanner data from supermarkets.

[1] Throughout this paper, all rates of change are computed on a logarithmic basis.

The general pattern that emerges from these data corroborates our findings from the aggregate data. Significantly, the disaggregated data reveal that even the retail peso price of goods for which imported and exportables have a higher market share rose by more than the price of goods produced solely for domestic consumption, so-called 'local goods'. For example, in the first year after a devaluation of 125 percent, the retail price of imported goods rose by more than 80 percent. In sharp contrast, the retail price of local goods rose by only 40 percent. Perhaps more importantly, the disaggregated data allow us to study the frequency of price adjustment for individual goods and services. Based on our survey evidence, we find that from March 2002 to December 2002 the median monthly frequency of price changes for tradable goods was 63 percent. For services, the quintessential nontradable product, it was *zero*.

Taken together, our evidence suggests that the key puzzle about the post-crisis behavior of prices is: why do the prices of nontradable goods and services respond by so little in the aftermath of large devaluations? To address this puzzle we consider the extreme case in which the prices of nontradable goods and services do not respond at all to a large devaluation. We then develop a model in which sticky nontradable prices can emerge, under plausible conditions, as an equilibrium outcome after a large devaluation.

We build on the large literature that analyzes price stickiness in closed economies. This literature identifies a class of models in which the gains from adjusting prices in response to changes in monetary policy can be very small. Indeed, these gains can be so small that price stickiness can be rationalized by appealing to small costs of changing prices. We incorporate into our analysis the key feature emphasized by Ball and Romer (1990): a flat marginal cost of producing output. In addition, as in Kimball (1995), we assume that the elasticity of demand for the output of a producer is increasing in its relative price.

There are two key differences between our analysis and the literature discussed above. First, we consider large changes in monetary policy instead of small changes. Second, and perhaps more importantly, we focus on open economies. Specifically, we consider a small open economy in which relative purchasing power parity (PPP) holds for imported goods at the dock. The other key features of the model are that:

- the share of tradable goods in consumption is small;
- the domestic distribution margin for imported goods is large;
- the elasticity of demand for exports is low; and
- the elasticity of substitution between tradables and nontradables is low.

We assume that the economy is initially in a fixed exchange rate regime and then consider a change in monetary policy that leads to a large, permanent devaluation. The key property of the post-devaluation equilibrium is that nontradable goods prices do not change. To establish this property we proceed as follows. We calculate the post-devaluation equilibrium assuming that the prices of nontradables does not change. We then compute the benefits to a producer of nontradable goods of deviating from a symmetric equilibrium by changing his price. We perform this calculation under two scenarios. In the first scenario, the only shock to the economy is the change in the exchange rate and the devaluation is expansionary. Since most large devaluations are contractionary, we also consider a second scenario in which the devaluation is accompanied by a reduction in net foreign assets. This reduction allows us to capture, in the simplest possible way, the negative wealth effects associated with contractionary devaluations.[2]

[2] See Burstein, Eichenbaum and Rebelo (2003) for a discussion of these wealth effects in a model with a richer specification of the real side of the economy.

In the benchmark version of our model we find that after an expansionary devaluation, the percentage increase in profits to a producer of nontradable goods who changes his price is only 0.28 percent. The present value of the loss of keeping prices constant *forever* is only 4.9 percent. These gains are sufficiently small that it is optimal for the producer to leave his price constant for a considerable period of time in the presence of modest costs of changing prices. Significantly, the gains from changing prices in the model are much smaller than the costs of changing prices estimated by Levy et al. (1997) and Zbaracki et al. (2003).

To assess the impact of sticky nontradable prices on inflation note that the CPI is a weighted average of tradable and nontradable good prices. In a flexible price equilibrium all prices would rise by the rate of devaluation. Consequently, a 40 percent devaluation would lead to a 40 percent rise in the CPI. Suppose, however, that nontradable good prices are sticky. Then our model implies that a 40 percent devaluation leads to a rise in the CPI of only 6 percent and a drop in the RER of 34 percent. All of this decline in the RER is due to the stickiness of nontradable good prices.

After a contractionary devaluation the percentage increase in profits to a producer of nontradable goods who changes his price is zero. To understand the effect of stickiness in nontradable good prices on the rate of inflation, it is useful to first consider what would happen under flexible prices. In that case, a 40 percent devaluation leads to a rate of inflation of 22 percent. The rate of inflation is lower than the rate of devaluation because of the negative income effect associated with a contractionary devaluation. This effect leads to a decline in the consumption of nontradable goods which generates a fall in the real (dollar) cost of producing nontradable goods. This fall mutes the overall rise in the inflation rate. However, in our model this effect is not strong enough to account for the rate of inflation that is observed in contractionary devaluation. This shortcoming is not present in the equilibrium with sticky nontradable prices.

The basic intuition for why producers of nontradable goods have little incentive to change prices in both expansionary and contractionary devaluations is as follows. In our model, the nontradable sector is monopolistically competitive. Firms in this sector set local currency prices as a markup over nominal marginal cost. This cost is proportional to the nominal wage rate. The fundamental role of the four open economy features noted above is to keep nominal wages stable after a large devaluation.

Consider, for example, the share of tradable goods in the CPI. A depreciation of the exchange rate raises the prices of tradables in local currency. Suppose that tradable goods have a small weight in the worker's consumption bundle. Then, other things equal, the rise in the price of tradable goods has a small effect on the CPI-deflated real wage. To maintain equilibrium in the labor market the nominal wage rate has to rise by a small amount. But, if this is true, a producer of nontradable goods would want to change his price by only a small amount. So the opportunity cost of not raising the price of nontradable goods would be small. Since the share of tradable goods in consumption plays a central role in our model, we provide evidence on this share for various countries.

Next, consider the role of domestic distribution costs. In our model we assume that consuming tradable goods requires using nontradable distribution services (wholesaling, retailing and transportation). These costs lower the effective weight of tradable goods in the CPI. For the reasons just discussed this reduces the incentive of nontradable good producers to raise their prices.

Consider next the role of the export industry. Other things equal, a devaluation leads to an expansion in the export sector since it reduces the costs of production measured in dollars. When this expansion is larger there is more pressure on real and nominal wages. A higher nominal wage increases the incentive to raise nontradable good prices. A low elasticity of demand for exports mutes the post-devaluation boom in the export sector. This reduces the post-devaluation rise in wages and moderates the incentive of nontradable good producers to raise their prices.

Finally, consider the role of the elasticity of substitution between tradables and nontradables. Other things equal, a devaluation induces a fall in the relative price of nontradable goods. If the degree of substitution between tradables and nontradables is large, this fall will lead to a large expansion in the nontradable sector. This expansion exerts upward pressure on real and nominal wages. To the extent that wages rise, so too do the incentives for nontradable firms to raise prices. Lower substitutability between tradables and nontradables leads to lower pressure on real wages.

The remainder of this paper is organized as follows. Section 2 provides empirical evidence on the behavior of nominal and real exchange rates, as well as on the response of different prices to large devaluations. Section 3 provides a more detailed analysis of the 2001 Argentinean devaluation. Section 4 provides evidence on the import content of consumption for sixteen countries. Section 5 presents our model and analyzes the effects of a large devaluation. Section 6 presents our basic results. Section 7 highlights the roles played by the different features of our model in accounting for sticky nontradable goods prices. Finally, section 8 contains some concluding remarks.

2. Decomposing Changes in the Real Exchange Rate

It is well known that the real exchange rate (RER), computed using the CPI, declines dramatically after large devaluations. In principle, this decline could reflect changes in the dollar price of tradable goods or nontradable goods and services. In this section we argue that changes in the dollar price of nontradables are the primary force at work. Our argument rests crucially on distinguishing between the price of traded goods at the retail level and 'at the dock'. In our framework the difference between these two prices represents distribution costs. We think of these costs as reflecting the use of nontradable goods and services to distribute traded goods to consumers. We present evidence that relative PPP is a good approximation for 'at the dock' prices, i.e. these prices move closely with exchange rates. In sharp contrast, our evidence suggests that the movement in nontradable good prices, measured in local currency, is relatively small. We conclude that this is the primary reason why CPI-based RER's exhibit significant declines after large devaluations.

The CPI can be viewed as a weighted average of the price of tradable (P_t^T) and nontradable goods (P_t^N). In reality, the CPI is typically computed as an arithmetic average. Here, for expositional purposes, we assume that the domestic (CPI_t) and US (CPI_t^*) consumer price indices are given by the geometric averages:

$$\begin{aligned} CPI_t &= (P_t^T)^{\omega}(P_t^N)^{1-\omega}, \\ CPI_t^* &= (P_t^{T*})^{\omega}(P_t^{N*})^{1-\omega}. \end{aligned}$$

The scalar ω denotes the share of tradable goods in the CPI bundle. We assume, for simplicity, that ω is the same in both countries. The logarithm of the CPI-based RER is given by:

$$\log(RER_t) = \log(CPI_t) - \log(CPI_t^*) - \log(S_t).$$

Following Engel (1999), we can rearrange this expression to decompose movements in the RER into deviations from PPP for tradable goods ($P_t^T/(S_t P_t^{T*})$) and movements in the relative price of nontradables in the two countries ($(P_t^N/P_t^T)/(P_t^{N*}/P_t^{T*})$):

$$\log(RER_t) = \log[P_t^T/(S_t P_t^{T*})] + (1-\omega)\left[\log(P_t^N/P_t^T) - \log(P_t^{N*}/P_t^{T*})\right]. \quad (2.1)$$

According to (2.1), movements in the RER are due to either changes in the dollar price of tradable goods or changes in the relative price of nontradables in the two countries.

This formula leaves open the question: how should we measure the price of tradable goods, 'at the dock' or at the retail level? This question is important because these prices behave very differently. Authors such as Engel (1999) and Chari, McGrattan and Kehoe (2002) use as their primary measure of P_t^T the retail price of tradable goods. For small movements in the exchange rate they find that movements in $\log[P_t^T/(S_t P_t^{T*})]$ are large, while movements in $\left[\log(P_t^N/P_t^T) - \log(P_t^{N*}/P_t^{T*})\right]$ are small. Consistent with Mussa (1986), they interpret these results as suggesting that the most important source of RER fluctuations is stickiness in traded good prices. In contrast with this literature we focus on large devaluations. Below we argue that, for these types of episodes, it is critical to incorporate at the dock prices into the analysis.

Table 1 summarizes the behavior of prices and exchange rates in the aftermath of four large devaluation episodes: Mexico (1994), Korea (1997), Brazil (1999), and Argentina (2001). The table reports cumulative logarithmic changes at various horizons. The variables reported in Table 1 are the US$ nominal exchange rate, the trade-weighted nominal exchange rate, the CPI-based real exchange rate (RER) computed using the trade-weighted nominal exchange rate, import and export prices, and the CPI.[3] We also report data for the CPI disaggregated into the retail price of tradable goods and the prices of nontradable goods and services.[4]

Table 1 provides evidence that prices of imports and exports move closely with the nominal exchange rate. In Mexico, Brazil and Argentina, this close

[3] For availability reasons we use import and export price indexes for Korea, Brazil and Argentina and import and export deflators from the national income account statistics for Mexico.

[4] We classified goods into tradable and nontradable. The most important nontradable goods are housing, health, education, and transportation.

comovement is present at all horizons that we consider.[5] For example, in the first three months import (export) prices in Brazil increased by 51 (37) percent, while the trade-weighted nominal exchange rate depreciated by 42 percent. For Korea the comovement is stronger in the first few months after the devaluation.[6] There is no evidence in our data that import or export local currency prices are sticky.

Table 1 also shows that the retail price of tradable goods moves much less than the price of imports and exports. For example, in the first three months after the Brazilian devaluation the change in the retail price of tradable goods was only 4.7 percent. Note also that the retail price of tradable goods moves more than the price of nontradable goods and services. In the first three months after the Brazilian devaluation the change in the price of nontradable goods was roughly 0.7 percent.

With these results as background, we now decompose movements in the CPI-based RER into movements in tradable and nontradable prices. Table 2 reports, for our four episodes, the change in $\log[P_t^T/(S_t P_t^{T*})]$ as a fraction of the total change in the logarithm of the RER. When P_t^T is measured using retail prices, most of the movement in the RER is accounted for by the change in the real price of traded goods. For example, in Korea the change in $\log[P_t^T/(S_t P_t^{T*})]$ represents between 77 and 98 percent of the movement in the $\log(RER)$ over various horizons. This result is consistent with the findings in Engel (1999) and Chari, Kehoe, and McGrattan (2002).

We now consider the impact of incorporating at the dock prices into the analy-

[5] This close comovement is consistent with the evidence of relatively high pass-through from exchange rates to import prices in industrialized countries, see Gordon (2000) and Campa and Goldberg (2001).

[6] The nominal exchange rate in Korea depreciated in the first three months after the currency crisis. It then began to appreciate. During the appreciation period, import and export prices fell by more than the nominal exchange rate. Two possible reasons for this price behavior are: (i) there was a general decline in dollar prices of tradable goods in the region; or (ii) there was a shift in import composition toward lower quality imports.

sis.[7] Suppose, as in Burstein, Neves and Rebelo (2003), that selling one unit of an imported good requires nontradable distribution services. For now we assume that the technology used to transform pure traded goods into retail tradable goods is Cobb-Douglas. In addition, we suppose that the price of distribution services coincides with the price of nontradable goods. Perfect competition in the distribution sector implies that the retail price of a tradable good is:

$$P_t^T = (\bar{P}_t^T)^{1-\phi}(P_t^N)^{\phi}. \tag{2.2}$$

Here $\bar{P}_t^T$ denotes the price of tradable goods at the dock. The parameter ϕ denotes the weight of nontradable goods and services in the production technology for retail tradable goods. The domestic distribution margin, defined as the fraction of the final price accounted for by distribution costs, is ϕ.

Using (2.2), we express the RER as:

$$\log(RER_t) = \log[\bar{P}_t^T/(S_t P_t^{T*})] + [1-\omega(1-\phi)]\log(P_t^N/\bar{P}_t^T) - (1-\omega)\log(P_t^{N*}/P_t^{T*}).$$

If, in fact, $\bar{P}_t^T$ is sticky, as envisioned in many models, this should yield the same results as the calculations based on (2.1) because the percentage change in $\log[P_t^T/(S_t P_t^{T*})]$ and $\log[\bar{P}_t^T/(S_t P_t^{T*})]$ should be about the same. This is not the case. Table 2 reports the change in $\log[\bar{P}_t^T/(S_t P_t^{T*})]$ as a fraction of the total change in the logarithm of the RER in the aftermath of several large devaluations. Notice that the fraction of the movement in the RER that is accounted for by changes in $\log[\bar{P}_t^T/(S_t P_t^{T*})]$ is much smaller than that accounted for by changes in $\log[P_t^T/(S_t P_t^{T*})]$. For example, at a six month horizon the change in

[7] Table 2 also reports results using the Producer Price Index (PPI) as a measure of P_t^T. We do so only for completeness. We think that the PPI is a poor measure of tradable goods prices for two reasons. First, the direct weight of nontradables in the PPI is significant. For the US we estimate that this weight is roughly 34 percent. Second, intermediate industrial and capital goods have non-negligible distribution costs. For the US, Burstein, Neves and Rebelo (2003) estimate that the distribution margin for these goods is 16 percent.

$\log[\bar{P}_t^T/(S_t P_t^{T*})]$ represents only 21, 25, 7, and 19 percent of the movement in the $\log(RER)$ for Korea, Mexico, Brazil, and Argentina, respectively.

It is worth noting that, if $\bar{P}_t^T$ was initially sticky, but adjusted gradually over time, we would expect the fraction of the change in $\log(RER_t)$ accounted for by changes in $\log[\bar{P}_t^T/(S_t P_t^{T*})]$ to fall over time. Table 2 indicates that, with the exception of Argentina, exactly the opposite is true. For example, in Mexico's case this fraction rises over time from roughly 25 percent to 40 percent.

Viewed as a whole, the evidence in this section suggests that, once distribution costs are taken into account, most of the movements in the RER after a large devaluation are due to changes in the dollar price of nontraded goods.

3. A Closer Look at the Data: The Argentina December 2001 Devaluation

We complement the evidence presented above with an in-depth look at an episode for which we have more detailed data: the Argentine December 2001 devaluation. Our information comes from three different data sets: (i) disaggregated CPI data from Indec (the Argentinean National Statistical Agency); (ii) data from our own survey of prices in Buenos Aires; and (iii) scanner data compiled by CCR, an Argentine marketing research firm.

Disaggregated CPI and Scanner Data

Table 3 describes the behavior of various price indices for the period December 2001 to December 2002. The same patterns of price behavior emphasized in the previous section emerge clearly here. During the period under consideration the US dollar/peso exchange rate fell by roughly 125 percent.[8] Consistent with the notion that relative PPP holds approximately at the dock, the price of imports

[8] As above, all rates of change are computed on a logarithmic basis.

at the dock rose by 111 percent. Consistent with the importance of distribution costs, the retail price of imported goods rose by substantially less (83 percent). The retail price of tradable goods (a category that includes both imported and local goods) rose by only 53 percent. The table also reveals that the retail price of tradable goods with the lowest market share of importables and exportables rose the least. For example, the retail price of local tradable goods, i.e. goods produced primarily for domestic consumption, rose by only 42 percent. Finally, Table 3 is consistent with the notion that the price of nontradable goods and services was not substantially affected by the devaluation. Indeed, the price of these goods rose by only 9 percent.[9]

An interesting illustration of the how the prices of different goods react to the exchange rate emerges from the airline industry. Table 4 presents data obtained from Indec on the rate of change of the price of flights between Buenos Aires and different cities for the period December 2001 to December 2002. The key thing to notice is that the price of domestic flights changed very little. In contrast, the change in the price of international flights is similar to the rate of devaluation. For example, the airfare to Mendoza increased by 18 percent while the airfare to Santiago, Chile rose by 113 percent. There are several alternative explanations for these differences, e.g. price discrimination may play some role. But perhaps the most obvious interpretation is that, because of regulation and lack of foreign competition, domestic flights are best thought of as a nontradable good. In contrast, international flights are best thought of as a traded good, since there are many international carriers that fly to Buenos Aires.

[9] The low rates of inflation for nontradable goods cannot be accounted for by the fact that the prices of some of these goods are controled by the goverment. The rate of change for these controled prices was indeed very low: 5 percent. However, the rate of inflation for privately provided nontradables was also relatively low: 15 percent.

We now present additional evidence that the rate of increase in retail prices is higher for goods that have a higher market share of imported and exportable goods. This evidence is based on two sources. First, we obtained scanner data on prices and market shares of individual products at the SKU (stock keeping unit) level from CCR, an Argentine marketing research firm. The data covered 21 supermarket product categories for the period from January 1999 to June 2002. For each product category we have information on a very large number of individual products. For example, we have information on 1042 different types of breakfast cereal.

Second, we conducted our own survey of product origin for a subset of individual items in the CCR data set. This subset represents approximately 70 percent of the total market share for each product category. The survey was conducted in October 2002 in several Buenos Aires supermarkets. We classified each individual product as being either imported, exportable, or domestic (i.e. produced solely for the domestic market).[10] We then cross tabulated this information with the CCR and Indec data for inflation at the level of product category, over the period December 2001 to June 2002. Table 5 presents data for the share of exportables and imported goods for each product category and the corresponding inflation rate.

Our major finding is as follows: there is a strong positive correlation (0.69) between the rate of inflation of a product category and the market share of imported and exportables in that product category. This positive correlation is consistent with the evidence in Table 3: at the retail level, inflation rates are highest for imported goods, lower for exportables, and even lower for domestic goods.

Our Survey of Prices in Buenos Aires

[10]The product package reports whether the product is imported, exported or neither. Our classification was based on this information.

The CCR data does not contain information on nontradable goods and services. We now turn to a data set that allows us to assess whether the retail prices of tradables and nontradable goods are adjusted at different frequencies. Using this data set, we show that the retail price of tradable goods changes much more frequently than the price of nontradable goods.

The data we used is based on our own survey of prices in Buenos Aires conducted between March 27 and December 24, 2002. We collected weekly prices for 53 goods and 10 services in two different outlets. Good prices were collected in a set of eight supermarkets. Each service price was collected from one or two locations. All of the goods that we considered would be classified as tradable under a standard classification. Of course, in practice, there is substantial heterogeneity in the extent to which these goods are tradable, reflecting, for example, different transportation costs. In contrast, the services that we surveyed are all clearly nontradable in nature.

The goods surveyed are: apples, aspirin, bananas, band-aids, batteries, bedsheets, Big Macs, Bic pens, bleach, blue jeans, bottled beer, bread, cereal, chicken, chocolate, chocolate biscuits, cigarettes, coffee, color film, computer mouse, cooking oil, two types of deodorant, diapers, diesel, diskettes, dulce de leche (a local desert), eggs, filet mignon, flour, gasoline, hake (an ocean fish), herbal tea (yerba mate), leather shoes, light bulbs, mayonnaise, milk, microwaves, mineral water, music CDs, ossobucco, polenta, potatoes, printers, printer paper, printer toner, recordable CDs, rice, shampoo, shaving blades, soft drinks, spaghetti, sugar, televisions, toothpaste, veal scallops, wine, and writing paper. The services surveyed were: bus fare, haircuts, movie theater, newspaper, parking, payphone, stamps, taxi, train fare, and video rental.

Table 6 reports the median frequency and median time between price changes for the different goods and services. Here frequency is defined as the number of periods in which a price change occurred as a fraction of the total number of periods in which the item was available.[11] Median time between price changes is defined as the inverse of the frequency of price changes. Our main finding is that the prices of goods are adjusted much more frequently than the price of services. Specifically, the median weekly frequency of price changes is 29.5 percent for goods and *zero* percent for services.[12] This implies that the median time between price changes across individual items is 5.5 weeks for goods and *infinity* for services.[13]

To compare our results with those reported by Bils and Klenow (2003) for the US, we also computed the monthly frequency of price changes using our data aggregated on a monthly basis.[14] Bils and Klenow (2003) estimate that the median monthly frequency of price changes is 30 percent for goods and 20.7 percent for services.[15] Our estimates of the median monthly frequency of price changes are 63 percent for goods and zero percent for services. These results indicate that goods prices adjusted much more rapidly in Argentina than in the US. In contrast, service prices adjusted much more slowly in Argentina than in the US.

We conclude this subsection by summarizing our main findings. First, relative PPP is a good description of the behavior of import prices at the dock in the case of Argentina. Second, the retail price of imported and exportable goods relative

[11]In practice, for a given good or service, the frequency of price changes was computed as an average of the frequency of price changes in different supermarkets or locations.

[12]The low frequency of price adjustment for nontradable services is not driven by the fact that the government controls some of these prices. The median weekly frequency of price changes for services whose price is not administered by the government is still very low: 1.8 percent.

[13]Interestingly, using a survey of daily data, we found that most price adjustments occur after a stock-out. The probability of a price change, conditional on the good not being on the shelf on the previous day, is 33.3 percent. This evidence is consistent with Rotemberg's (2003) argument that retailers worry about customer anger associated with price changes.

[14]Bils and Klenow (2003) have a more comprehensive sample of goods and services and rely less on supermarket items.

[15]Lach and Tsiddon (1992) study the frequency of price changes for 26 food items in Israel from 1978 to 1982. During this period the average rate of inflation was 15 percent. They find that the frequency of monthly price adjustment was 41 percent.

to nontradables rose substantially in the wake of the devaluation. Finally, the frequency of price adjustment is much larger for tradables than for nontradables.

4. The Importance of Imports and Exportables in Consumption

Above we documented that the key determinant of RER movements after large devaluations is the sluggish response of nontradable good prices. The theory that we develop below depends critically on the share of tradable goods in consumption. In this section we present evidence on this share for the four countries considered in Table 1, as well as for 16 additional countries for which data is available. The information is based on input-output tables except for Brazil and Thailand, for which we used national income accounts data.

Table 7 reports two measures of the importance of pure tradables in consumption. The first measure is the fraction of imported final goods in total consumption exclusive of distribution services. We refer to this measure as the direct import content of consumption. The second measure is the direct import content plus the value of imported intermediate inputs used to produce final consumption goods as a fraction of total consumption expenditures. We refer to this measure as the total import content of consumption.

In principle, we would also like to report the fraction of consumption represented by exportable goods. But, in practice, input-output matrices are organized in a way that makes it difficult to extract this information. The basic problem is that we do not have information on the fraction of exportable goods that is consumed domestically. We briefly return to this issue when we discuss how we calibrated the model.

For the four countries we have emphasized so far, Brazil, Korea, Mexico, and Argentina, the importance of pure tradables in consumption is relatively small.

The direct import content of consumption is lower than 5 percent. The total import content of consumption is lower than 18.2 percent.

Table 7 reveals substantial heterogeneity in the importance of imports and exportables in consumption. At the low end we have the US and Japan. For example, the direct import content of consumption is less than 5 percent for both of these countries. At the high end we have the Netherlands, Chile, and Norway, where the direct import content of consumption is roughly 16.5 percent. In our experiments below we will examine the implications of heterogeneity in the importance of pure traded goods in consumption. For completeness Table 7 also reports the direct and total import content of investment. Investment goods generally have a higher import content than consumption goods.

We conclude this section by contrasting our measures of pure tradables in consumption with a standard measure used in the literature. The standard measure is based on the assumption that all goods (inclusive of distribution services) are tradable and all services are nontradable. For example, in Korea, Mexico and Argentina, these numbers are 55, 68 and 46 percent, respectively.[16] These estimates exceed ours by at least a factor of 2. An important reason for the difference between standard estimates of the weight of tradable goods in consumption and the import content of consumption is that many goods that are typically classified as tradables are actually local goods. By local goods we mean goods that are produced solely for the domestic market.[17]

[16] These number are based on input-output tables and are comparable to the share of expenditures on goods in the CPI basket. The CPI shares are 48, 54, 52, and 53 percent for Korea, Mexico, Brazil, and Argentina. The main discrepancy between these values and the ones reported in Table 2 stem from: (i) the CPI shares and the input-output matrices being estimated on different dates; and (ii) the fact that housing services are included in the CPI but are, for the most part, excluded from the input-output tables.

[17] See Burstein, Eichenbaum and Rebelo (2003) for a discussion of these local goods.

5. The Model

In the previous sections we documented that the primary source of the fall in the RER that occurs after a large devaluation is the slow adjustment in the prices of nontradable goods and services. In this section we propose an explanation for this finding. We build on the literature that studies price stickiness in closed economies. Specifically, we pursue an open economy version of the closed economy arguments proposed by Ball and Romer (1990) and Kimball (1995). These authors propose a class of models in which the gain from adjusting prices in response to a change in monetary policy is very small. Indeed, the gains can be so small that price stickiness emerges as an equilibrium if there are small costs to changing prices. The model proposed by those authors have the following key features: (i) a flat marginal cost of producing output; and (ii) a variable elasticity of demand for the output of the firms setting prices. Both features are present in our model. We incorporate four additional features, motivated by the open economy nature of our model: (i) the share of tradable goods is small; (ii) the distribution margin for domestic distribution of imported goods is large; (iii) the elasticity of substitution between tradables and nontradables is low; and (iv) the elasticity of demand for exports is low. We now provide a detailed description of our model.

The Export Sector Exports are produced by a continuum of monopolistically competitive producers indexed by i. The size of this sector has measure one. Firm i uses labor (N_{it}^X) to produce X_{it} units of exportable good i according to the following constant returns to scale production function:

$$X_{it} = A^X N_{it}^X.$$

The demand for this good in the world market is given by:

$$X_{it} = (P_{it}^*)^{-\gamma}.$$

The variable P_{it}^* denotes the dollar retail price of export good i. The elasticity of demand for this good is given by $\gamma > 1$.

We assume, as in Corsetti and Dedola (2002), that to sell a unit of the exported good to foreign consumers, foreign retailers must add ϕ^* units of foreign distribution services. To simplify, we normalize the dollar price of these services to one and assume that the distribution industry is competitive. It follows that P_{it}^* is given by:

$$P_{it}^* = \bar{P}_{it}^X / S_t + \phi^*. \tag{5.1}$$

Here $\bar{P}_{it}^X$ is the producer price of the exported good and S_t is the exchange rate expressed in units of local currency per dollar. These assumptions capture the idea, emphasized in Corsetti and Dedola (2002), that the presence of distribution costs affects the elasticity of demand for exports. In our model this elasticity is given by:

$$\frac{dX_{it}}{d\bar{P}_{it}^X} \frac{\bar{P}_{it}^X}{X_{it}} = -\gamma(1 - s^*), \tag{5.2}$$

where $s^* = \phi^*/P_{it}^*$ is the distribution margin (the fraction of distribution costs in P_{it}^*). Note that a higher distribution margin implies that exporters face a lower effective elasticity of demand.

Producer i maximizes profits, given by:

$$\Pi_{it}^X = (\bar{P}_{it}^X - W_t/A^X) X_{it},$$

where W_t denotes the nominal wage rate. The first-order conditions for this problem imply that all exporters charge the same price:

$$\bar{P}_t^X / S = \frac{\gamma (W_t/S_t)/A^X + \phi^*}{\gamma - 1}. \tag{5.3}$$

For future reference, we note that the elasticity of $\bar{P}_t^X/S$ with respect to W/S is:

$$\frac{d(\bar{P}^X/S)}{d(W/S)} \frac{(W/S)}{(\bar{P}^X/S)} = \frac{1}{1 + \frac{s^*}{\gamma(1-s^*)-1}}, \tag{5.4}$$

and the elasticity of exports with respect to the dollar wage is:

$$\frac{dX}{d(W/S)}\frac{(W/S)}{X} = \gamma\left(1 - \frac{\gamma}{\gamma - 1}s^*\right). \tag{5.5}$$

Total profits in the export sector are given by:

$$\Pi_t^X = \int_0^1 \Pi_{it}^X di.$$

The final nontradable good The final nontradable good (Y_t^N) is produced by competitive firms using a continuum of differentiated inputs, y_{it}^N. As in Kimball (1995), we assume that the production technology is given by the following implicit function:

$$1 = \int_0^1 G(y_{it}^N/Y_t^N)di, \tag{5.6}$$

where $G(1) = 1$ and $G'(1) = 1$. The standard Dixit-Stiglitz specification is a special case of this formulation where the function $G(\cdot)$ takes the form:

$$G(y_{it}^N/Y_t^N) = (y_{it}^N/Y_t^N)^{(\mu-1)/\mu}. \tag{5.7}$$

The representative firm maximizes profits,

$$\Pi_t^N = P_t^N Y_t^N - \int_0^1 p_{it} y_{it}^N di, \tag{5.8}$$

subject to (5.6). The first-order condition for this problem is:

$$p_{it} = \lambda G'(y_{it}^N/Y_t^N)(1/Y_t^N),$$

where λ is the Lagrange multiplier associated with (5.6).

Since the sector is competitive, equilibrium profits are zero. It follows that the price of the final nontradable good is given by:

$$P_t^N = \frac{\int_0^1 p_{it}^N y_{it}^N di}{Y_t^N}.$$

The intermediate nontradable good Nontradable intermediate good i is produced by monopolist i according to the following technology:

$$y_{it}^N = A^N N_{it}^N.$$

Monopolist i chooses a price p_{it} and commits to satisfying demand at this price. The monopolist's objective is to maximize profits:

$$\Pi_t^N = p_{it} y_{it}^N - W_t y_{it}^N / A^N.$$

The optimal price is given by:

$$p_{it} = \left[\frac{\varepsilon(z_{it})}{\varepsilon(z_{it}) - 1}\right] \frac{W_t}{A^N}.$$

Here $z_{it} = y_{it}^N / Y_t^N$ denotes the market share of the ith producer and $\varepsilon(z_{it})$ is the elasticity of demand for intermediate nontradable good i:

$$\varepsilon(z_{it}) = -\frac{G'(z_{it})}{z_{it} G''(z_{it})}.$$

The functional form that we adopt for $\varepsilon(z_{it})$ is given by:[18]

$$\varepsilon(z_{it}) = \begin{cases} \varepsilon^L, & \text{if } z_{it} \geq 1 + \bar{z}, \\ \varepsilon^H, & \text{if } z_{it} \leq 1 - \bar{z}, \\ \frac{1}{2\bar{z}} \left[(1 + \bar{z} - z_{it}) \varepsilon^H + (z_{it} - 1 + \bar{z}) \varepsilon^L \right], & \text{if } 1 - \bar{z} \leq z_{it} \leq 1 + \bar{z}. \end{cases} \tag{5.9}$$

This specification implies that, in a symmetric equilibrium ($z_{it} = 1$), the markup common to all the monopolists is:

$$\varepsilon(1) = \frac{\varepsilon^H - \varepsilon^L}{2}.$$

Given a value for $\bar{z}$, the parameters ε^L and ε^H jointly determine the average markup and the local slope of the markup around the point $z_{it} = 1$. Given ε^H we

[18] We are thankful to Miles Kimball for suggesting this functional form.

choose ε^L so that $\varepsilon(1) = \mu$. With these assumptions, the symmetric equilibrium is identical to that which obtains when $G(\cdot)$ takes the Dixit-Stiglitz form, (5.7).

In practice, we set $\bar{z}$ to a very small number (0.0001) so that $\varepsilon(z_{it})$ is close to a step function. Therefore a firm that deviates from a symmetric equilibrium by raising its price faces a discrete increase in the elasticity of demand for its product.

In the standard Dixit-Stiglitz case the function $G(\cdot)$ takes the form (5.7) and $\varepsilon(z_{it}) = \mu$ so that p_{it} is a constant markup over marginal cost. So, relative to the Dixit-Stiglitz case, firms in our model have less of an incentive to raise their prices.

The import sector We assume that the dollar price of imports is set in international markets and is invariant to the level of domestic consumption. For convenience we normalize this price to one. By assumption, PPP holds at the producer level, so:

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

where $\bar{P}_t^T$ denotes the domestic producer price of imports. As in Burstein, Neves and Rebelo (2003) and Erceg and Levin (1996), we assume that selling a unit of an imported good requires ϕ units of the final nontradable good. Perfect competition in the distribution sector implies that the retail price of imported goods is given by:

$$P_t^T = S_t + \phi P_t^N. \tag{5.10}$$

The domestic distribution margin, defined as the fraction of the final price accounted for by distribution costs, is given by $\phi P_t^N / P_t^T$.

Households The household values streams of consumption services (C_t), hours worked (N_t), and real balances. Consumption services are produced using tradable

(C_t^T) and nontradable (C_t^N) goods. Lifetime utility (U) is given by:

$$U = \sum_{t=0}^{\infty} \beta^t [u(C_t, N_t) + v(M_t/P_t)], \;\; 0 < \beta < 1.$$

Here, M_t represents beginning of period nominal balances, P_t denotes the price level, and $v(M_t/P_t)$ is a strictly concave function. The function $u(C_t, N_t)$ takes the form proposed in Greenwood, Hercowitz, and Huffman (1988):

$$u(C_t, N_t) = \frac{1}{1-\sigma} \left(C_t - B \frac{N_t^{1+\theta}}{1+\theta} \right)^{1-\sigma}. \tag{5.11}$$

With this momentary utility function there are no wealth effects on labor supply. The uncompensated labor supply elasticity, $1/\theta$, is the same as the Frisch elasticity.

Consumption services, C_t, are produced using C_t^T and C_t^N according to the CES technology:

$$C_t = \left[\nu^{\frac{1}{\rho}} (C_t^T)^{\frac{\rho-1}{\rho}} + (1-\nu)^{\frac{1}{\rho}} (C_t^N)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}, \nu \geq 0. \tag{5.12}$$

In equation (5.12), the parameter ρ governs the elasticity of substitution between C_t^T and C_t^N. With ρ equal to ∞, 1, and 0, we obtain the case of perfect substitutes, Cobb-Douglas, and Leontieff, respectively. Note that, for simplicity, we have assumed that the representative household does not consume the exportable good. The price of consumption services, P_t, is given by:

$$P_t = \left[\nu \left(P_t^T \right)^{1-\rho} + (1-\nu) \left(P_t^N \right)^{1-\rho} \right]^{\frac{1}{\rho-1}}. \tag{5.13}$$

Here P_t^T and P_t^N are the local currency prices of tradables and nontradable goods, respectively.

The household can borrow and lend in international capital markets at the risk free rate r. Its flow budget constraint is given by:

$$P_t^T C_t^T + P_t^N C_t^N + S_t a_{t+1} + M_{t+1} - M_t + S_t T_t =$$
$$W_t N_t + \Pi_t + (1+r) S_t a_t.$$

The variable a_t denotes the household's net foreign assets. The variables W_t and T_t represent the nominal wage rate and nominal government transfers to the household, respectively. Total nominal profits in the economy are given by Π_t. We impose the no-Ponzi game condition:

$$\lim_{t\to\infty} \frac{a_{t+1}}{(1+r)^t} = 0.$$

Government The government chooses a money supply sequence $\{M_t^s\}_{t=1}^{\infty}$ and rebates any seignorage revenue to the household via lump-sum transfers. This implies:

$$M_{t+1}^s - M_t^s = T_t.$$

Equilibrium A perfect foresight competitive equilibrium for this economy is a set of paths for quantities $\{X_{it}, N_{it}^X, y_{it}^N, Y_t^N, N_{it}^N, C_t, C_t^N, C_t^T, N_t, a_{t+1}, M_{t+1}\}$ and prices $\{P_{it}^*, \bar{P}_{it}^X, W_t, S_t, p_{it}, P_t^N, \bar{P}_t^T, P_t^T\}$ such that: (i) households maximize their utility and firms maximize profits; (ii) the government's budget constraint holds; and (iii) the goods, labor, money, and exchange rate markets clear. Throughout we restrict our attention to symmetric equilibria in which all nontradable good producers choose the same price and quantity.

Our Experiment Prior to time zero, agents anticipate that the exchange rate will remain fixed at $S_t = S$ and that the economy will remain in a steady state with constant values for all prices and quantities. At time zero there is an unanticipated change in monetary policy that leads to a one time permanent exchange rate devaluation.

In an economy with flexible prices this change in monetary policy has no real effects and the change in the price level coincides with the devaluation rate.[19] This specification clearly cannot account for the facts discussed in sections 2 and 3. Here we analyze two alternative specifications in which nontradable prices are sticky. In the first specification, the only shock to the economy is the change in the exchange rate and the devaluation is expansionary. In the second specification, the devaluation is accompanied by a reduction in net foreign assets. This assumption allows us to capture, in the simplest possible way, the negative wealth effects associated with contractionary devaluations. We will distinguish between the impact of the wealth effect and sticky nontradable good prices on the CPI.

Benchmark Calibration We now discuss the parameter values for our benchmark model, summarized in Table 8. We consider three categories of parameters. The first set is calibrated to replicate features of the Korean economy. The second set of parameters are taken from the literature. The last set of parameters are those for which we have relatively little a priori information. Our strategy for these parameters is to choose values for which the model can generate sticky nontradable prices in the presence of costs of changing prices. We then assess the robustness of our results to perturbations in these parameters.

We first discuss the parameters calibrated using Korean data. Throughout we consider an unanticipated, permanent change in the exchange rate of 40.6 percent. This coincides with the rate of devaluation in the first year after the Korean currency crisis. The pre-devaluation exchange rate is normalized to one. We set ν, the share parameter in the CES consumption aggregator in equation (5.12) to 0.15. This assumption implies that, given our value of ρ (see below), the pre-devaluation share of tradable goods in consumption, inclusive of distribution costs, is 25 percent. This value coincides with our estimate for Korea, which we

[19] In this case the devaluation is associated with a one time increase in the money supply and a corresponding one time increase in the price level.

obtained by adding the direct import content consumption (4.3 percent) and an estimate of the importance of indirect importables, exportables, and distribution services.

We chose the elasticity of demand for exports, γ, to equal 2.3. The primary function of this parameter is to control how much the export sector expands in the wake of the devaluation. In reality, there are many real and financial factors that limit the speed with which the export sector can expand. To simplify our analysis we abstract from these factors. So the key force in our model limiting the expansion of exports is the elasticity of foreign demand. For this reason we require a very high value of γ to yield a plausible expansion of the export sector. In conjunction with the other parameter values, our benchmark value for γ implies a pass-through from the exchange rate to export prices of 80 percent. This is roughly the pass-through rate in Korea three months after the devaluation.

The value of the level parameter that controls the disutility of labor, B, is set to 0.66. In conjunction with the other parameter values, this implies that the price of nontradables in the pre-devaluation steady state is 1. We set the level parameter in the production function of the export sector A^X to 15.4 and the initial level of net foreign assets (a_0) to -4.84.[20] This generates a share of exports to GDP of 32 percent, which is consistent with pre-crisis Korean data.

We now discuss parameter values taken from the literature. We set $\phi = 1.00$ and $\phi^* = 0.56$. These values imply a pre-devaluation distribution margin of 50 percent, both in the domestic and foreign market. This value is consistent with the evidence in Burstein, Neves, and Rebelo (2003).[21] We assume that $\theta = 0.25$.

[20] In order for the model to generate a sizable fraction of the workforce in the export sector the value of net foreign assets must be a large negative number. Since we abstract from investment and pure importables are a small fraction of consumption, there is no reason to have large exports except to pay off the initial foreign debt.

[21] See Goldberg and Verboven (2001, 2003) for additional evidence, based on the European car market, on the importance of distribution costs in determining the pass-through from exchange

This value implies a labor supply elasticity of 4 which coincides with the standard value of the Frisch labor supply elasticity used in the real business cycle literature (see Christiano and Eichenbaum (1992) and King and Rebelo (2000)).

We now turn to the third set of parameters. Consider the intermediate demand aggregator. We choose ε^L and ε^H so that the model has two properties. First, consistent with estimates in Christiano, Eichenbaum and Evans (2003), the steady state markup is 20 percent. Second, consistent with Kimball (1995) and Chari, Kehoe and McGrattan (2000), the elasticity of demand changes by roughly 33 percent in response to a 1 percent change in the price. Finally, we set the elasticity of substitution between tradables and nontradables (ρ) to 0.10. In our view, a low value of ρ is plausible given that tradables include items such as food and clothing and nontradables include items such as education, housing and health. Below we assess the sensitivity of our results to changes in the benchmark values of ε^L, ε^H and ρ.

Finally, note that given the experiments we perform, the function $v(.)$ has no impact on the model's implications for the variables that we consider.

6. Experiments

The first two columns of Table 9 report the response of the benchmark model to a single shock: a 40.6 percent devaluation. Columns one and two correspond to the case of flexible and sticky nontradable good prices, respectively. We label these columns 'expansionary' in anticipation of the well-known result that in the presence of sticky prices, a devaluation leads to an expansion in economic activity. The last two columns report the impact of two simultaneous shocks: a 40.6 percent devaluation that coincides with a negative wealth shock. Columns three and four report results for the flexible and sticky price case, respectively. We label these

rates to retail prices.

columns 'contractionary'.

An Expansionary Devaluation The first column of Table 9 reports the response of the economy to a permanent devaluation when prices are flexible. In this case the devaluation has no impact on quantities. In addition, all prices, including the nominal wage, increase by 40.6 percent.

The second column reports results for the sticky price case. With respect to prices, the key results are as follows. CPI inflation is only 6.1 percent. There is a moderate rise in the retail price of imported goods (22.3 percent) and the price of export goods rises less than the rate of devaluation (33.8 versus 40.6 percent).

Next, note that the nominal wage rate rises by only 7.3 percent. The intuition for why the change in the nominal wage is so much smaller than in the flexible price case is as follows. After the devaluation there is a roughly 5 percent rise in employment, so the real wage must rise. The real wage that is relevant for labor supply decisions is the CPI-deflated real wage which rises by 1.2 percent.[22] Since CPI inflation is only 6.1 percent the required rise in the nominal wage is only 7.3 percent. The dollar denominated wage falls by 33.3 percent, but this is not relevant for labor supply decisions. Most of the worker's consumption basket is composed on nontradable goods whose price has not changed. As a result, CPI and dollar deflated real wages respond very differently to the devaluation.

Table 9 indicates that the dollar price of exports ($\bar{P}^X/S$) drops by 6.8 percent, while the dollar wage (W/S) declines by 33.3 percent. The decline in $\bar{P}^X/S$ generates a fall in the foreign retail price of exported goods and a rise in exports. Consequently, employment in the export sector rises (by 7.6 percent). To understand the wedge in the responses of $\bar{P}^X/S$ and W/S, note that a decline in the

[22] The CPI reported in Tables 9 and 10 is computed using an arithmetic average of prices. In practice, the rate of change in this CPI is very similar to the rate of change of the theoretical price index (5.13) that corresponds to the household's utility function.

dollar wage reduces the marginal cost of producing export goods. The optimal response of export good producers is to lower their dollar price to sell more units. Consistent with (5.4), in the absence of foreign distribution costs ($\phi^* = 0$), the percentage decline in $\bar{P}^X/S$ would be the same as the percentage decline in W/S. But, as emphasized by Corsetti and Dedola (2003), when $\phi^* > 0$, a one percent decline in the dollar price of exports ($\bar{P}^X/S$) induces a less than 1 percent decline in the retail dollar price of exports. Consequently, the price reduction induces a smaller rise in the demand for the product. Put differently, a positive value of ϕ^* reduces the effective elasticity of demand with respect to $\bar{P}^X/S$. So the optimal response of the monopolist is to lower $\bar{P}^X/S$ by less than when $\phi^* = 0$.

The demand for both imported and nontradable goods rises because dollar export revenues increase. The fall in the relative price of nontradables induces a further rise in the demand for nontradable goods. By assumption, nontradable good firms must satisfy demand at fixed prices so nontradable employment rises (by 4.8 percent). Since employment in both the export and nontradable sector increases so does overall employment.

As a result of the devaluation, the markup of nontradable producers falls from 20 to 11.6 percent. A key question is: how large is the incentive of an individual firm to deviate from the symmetric equilibrium? According to Table 9, the optimal markup for the deviator is 12.5 percent and the percentage increase in his profits is only 0.28 percent. This implies that the present value of the loss of keeping prices constant *forever* is only 4.9 percent.[23] This gain is sufficiently small that the monopolist would leave his price unchanged for a prolonged period of time in the presence of modest costs of changing prices. Below we discuss the sensitivity

[23] This present value calculation is meaningful only when the comparison of the costs and benefits of changing prices is roughly invariant with respect to the model's time frequency. One way to ensure this is as follows. Suppose that time is measured in intervals of length n years, so $n = 1/12$ means that time is measured in months. Then the costs of changing prices must be proportional to $1/n$.

of this result to changes in key parameter values.

A Contractionary Devaluation There is a large literature discussing different mechanisms through which a large devaluation can lead to a contraction in economic activity.[24] Embedding these mechanisms into our framework would greatly complicate the model. Instead, we adopt a simple way of generating a recession. We assume that net foreign assets, a_0, decline at the time of the devaluation. This decline captures in a direct, albeit brute force manner, the decline in real wealth that is a hallmark of contractionary devaluations. Arguably, the fall in a_0 can be thought of as a proxy for the balance sheet effects emphasized by some authors. We calibrate the change in a_0 so that our benchmark model generates a fall in real consumption consistent with that observed in Korea in the aftermath of their 1997 crisis.

Column 3 of Table 9 summarizes the response of the economy to a contractionary devaluation when all prices are flexible. Notice that a 40.6 percent devaluation leads to only a 22 percent rise in the CPI. This wedge reflects the negative income effect associated with a contractionary devaluation that induces a decline in the real wage and in the relative price of nontradables.

The intuition for why the real wage drops is as follows. Given our assumptions on preferences, the negative wealth effect has no direct impact on labor supply. But it does lead to a decline in the demand for nontradable consumption goods. At the same time, the fall in the dollar denominated wage leads to a rise in the demand for labor in the export sector.[25] The contraction in the nontradable sector outweighs the expansion in the export sector. Consequently equilibrium

[24] See, for example, Aghion, Bachetta and Banerjee (2001), Burnside, Eichenbaum and Rebelo, (2001), Caballero and Krishnamurty (2002), and Christiano, Gust and Roldos (2003).

[25] See Burstein, Eichenbaum and Rebelo (2003) for evidence on the expansionary effect of a contractionary devaluation on exports.

employment falls. This fall is associated with a decline of 2.9 percent in the CPI-deflated real wage.

The intuition for why CPI inflation is lower than the rate of devaluation (22.7 versus 40.6 percent) is as follows. Since the CPI-deflated real wage drops, so does the real marginal cost of producing nontradable goods. This mutes the inflationary impact of the devaluation on the price of nontradable goods. The net result is that the CPI rises less than the rate of devaluation. Still, the rate of inflation in the model is much larger than that observed in contractionary devaluations. Column 4 of Table 9 shows that this shortcoming is not present when nontradable good prices are sticky. In that case, a 40.6 percent devaluation leads to only a 6 percent rise in the CPI.

Finally, we turn to the question: how large is the incentive of a nontradable monopolist to deviate from the sticky price equilibrium? The key result here is that this incentive is much smaller in a contractionary devaluation than in an expansionary one. From Table 9 we see that the gains to the deviator are zero. The reason why the gain from deviating is smaller in an expansionary devaluation is that nominal wages rise by less in a contractionary devaluation than in an expansionary devaluation.

7. Isolating the Key Margins

In this section we discuss the mechanisms that enable our model to account for sticky nontradable prices. First, we discuss our specification for the demand for nontradable goods. We then turn to the other parameters of the model.

The Demand Aggregator Recall that our specification of the demand for nontradable goods is consistent with the one chosen by Kimball (1995) and Chari, Kehoe and McGrattan (2000). Specifically, our calibration implies that the elasticity of demand changes by roughly 33 percent in response to a 1 percent change in price. To explore the sensitivity of our results to this specification we explore two alternatives. First, we choose the parameters of the nontradable demand aggregator (5.9) to be consistent with the specification proposed by Bergin and Feenstra (2000). We calibrate our aggregator to match the Bergin and Feenstra (2000) aggregator for a 1 percent increase in marginal cost. In their translog specification this increase in marginal cost leads to only a 5 percent fall in the elasticity of demand.[26] Second, we consider the standard Dixit-Stiglitz specification of demand.

The first row of Table 10 summarizes the benefit to a nontradable good producer of deviating from a symmetric equilibrium after a contractionary devaluation of 40.6 percent. As anticipated, this benefit is roughly zero in our benchmark specification. With the Bergin-Feenstra specification, this benefit rises to 0.5 percent, which is still reasonably small. However, once we move to the Dixit-Stiglitz specification, the benefit jumps to almost 2 percent. We conclude that, for a contractionary devaluation, our results are reasonably robust to modifications of the demand aggregator, as long as we do not go to the extreme of the Dixit-Stiglitz specification.

The second row of Table 10 presents the analogous results for an expansionary devaluation. Here the story is quite different. The benchmark specification implies a low benefit of deviating from a symmetric equilibrium (0.28 percent). But this benefit jumps to 7.5 percent as soon as we move to the Bergin-Feenstra specification. The benefit is even larger in the Dixit-Stiglitz case (11.1 percent). So we conclude that in the case of a 40.6 percent expansionary devaluation, inference

[26] In Bergin and Feenstra (2000) it is optimal for a deviator to respond to a 1 percent change in marginal cost by raising prices by 1/2 percent. This implies that the gross markup, $\varepsilon(z_{it})/[\varepsilon(z_{it})-1]$, falls by 1/2 percent. In our model marginal cost rises by 3.3 percent so the gross markup falls by roughly 1.65 percent.

is sensitive to deviations from the benchmark demand aggregator. Fundamentally, the difference between the contractionary and the expansionary devaluation is that nominal wages rise by more in the expansionary case (7.3 percent versus 3.3 percent). This leads to a much larger incentive to change prices.

While we considered a 40.6 percent expansionary devaluation for symmetry, it is difficult to think of an actual expansionary devaluation of this magnitude. For example, the 1992 Italian and British devaluations are often thought of as expansionary devaluations.[27] But the magnitude of these devaluations was much smaller than 40.6 percent. The changes in the trade-weighted nominal exchange rate were only 21 percent and 11 percent, respectively, in the first year after the devaluation. Interestingly, in the aftermath of the devaluation, inflation remained roughly the same in Italy (around 4.5 percent) and actually dropped in the UK (from 3.5 to about 2 percent).

In light of these considerations we think that the relevant empirical question is whether our model is robust to changes in the specification of demand for smaller expansionary devaluations. To address this question we proceed as follows. First, we adopt the Bergin-Feenstra demand specification. Second, we calculate the size of an expansionary devaluation that yields a benefit to a deviator identical to that associated with a 40.6 expansionary devaluation in the benchmark model (0.28 percent). We find that the size of this devaluation is 17 percent. Interestingly this is midway between the rates of devaluations in the Italian and British episodes alluded to above. Put differently, even if we adopt the Bergin-Feenstra specification of demand, our model can account for sticky nontradable good prices in the aftermath of empirically relevant large expansionary devaluations.

[27] See Gordon (2000) for a discussion of these devaluation episodes.

Other Parameters We now explore the sensitivity of our model to other key parameters. We conduct this analysis in the context of the expansionary devaluation because the intuition is easier to convey when only one shock is operative, i.e. there is no negative wealth effect. In light of the discussion in the end of the previous subsection, we take as our benchmark the case of a 17 percent expansionary devaluation. Table 11 reports results obtained by varying key parameters of the model. To make the results more easily interpretable, for every change in a model parameter we recalibrate the value of a_0 so that the share of exports in GDP before the devaluation remains the same. To economize on space we focus on the intermediate case in which the demand aggregator is consistent with the Bergin and Feenstra (2000) specification.

Consider first the impact of foreign distribution costs. Column 2 of Table 11 reports results for the case when the foreign distribution margin is zero instead of 50 percent. There is now a smaller rise in the local currency price of exports ($\bar{P}^X$): 9.4 versus 13.9. This translates into a larger fall in $\bar{P}^X/S$ (-7.6 versus -3.1). To understand this result, recall from (5.5) that a fall in ϕ^* raises the effective demand elasticity faced by producers of export goods. This makes it optimal for them to lower $\bar{P}^X/S$ by more than they do when ϕ^* is positive. The associated increase in demand leads to a larger expansion in export production and employment and a larger rise in the nominal wage (9.4 versus 2.9 percent) relative to the benchmark case. The larger rise in the nominal wage results in a lower post-devaluation markup for nontradable producers. This, in turn, generates a much larger incentive to raise prices: the percentage increase in profits associated with deviating from the symmetric sticky price equilibrium is much larger for all three specifications of the demand aggregator. The gains from deviating rise from 0.27 to 15.9 percent. Clearly, it is important to have large foreign distribution costs to rationalize the sticky price equilibrium.

The presence of foreign distribution costs may be important in understanding the different devaluation responses of developing countries versus industrialized countries. Developing countries export agricultural goods that have very large distribution margins.[28] So, other things equal, nontradable prices may remain sticky after a devaluation in a country like Brazil but they may change in a country like Italy.

Column 3 reports results obtained by changing the parameter ν so that the share of traded goods (inclusive of distribution) in the CPI bundle rises from 25 percent (in the benchmark model) to 50 percent. With this parameterization, a devaluation leads to a higher rate of CPI inflation (4.5 versus 2.3 percent). To understand the behavior of nominal wages suppose for the moment that employment remained constant. Then, given our preference specification, the real wage would also be constant. This would require a 4.5 percent rise in nominal wages. For reasons discussed above, with sticky prices, employment rises after a devaluation. So the real wage must rise. Thus, the nominal wage must increase by more than 4.5 percent (4.8 percent versus 2.9 percent in the benchmark).

The rise in wages has three important effects: (i) a smaller post-devaluation markup in the nontradable sector (14.3 percent); (ii) a larger spread between the markup of a deviator and a nondeviator; and (iii) a larger incentive for nontradable firms to change their prices. The benefit to the deviator rises from 0.27 to 2.09 percent of profits. So a modest share of pure traded goods in the CPI bundle is important for rationalizing sticky nontradable good prices.

Column 4 reports results obtained by eliminating domestic distribution costs. With $\phi = 0$, the model counterfactually implies that the change in the retail price of imported goods must equal the rate of devaluation. The other effects of setting

[28] Burstein, Neves and Rebelo (2003) document that distribution margins are substantially higher for agricultural goods than for the average consumption good.

$\phi = 0$ resemble those that result from a rise in the share of pure tradable goods in consumption. For example, the rate of CPI inflation is now higher. So, for the reasons discussed above, nominal wages must rise more than in the benchmark model. This, in turn, implies that there is a larger incentive for nontradable firms to change their price (2.5 versus 0.27 percent of profits). We infer that sticky nontradable prices are difficult to rationalize in our framework absent significant domestic distribution costs.

Column 5 reports results obtained by increasing the elasticity of substitution between tradables and nontradables from 0.1 to 1. In this new specification preferences are Cobb-Douglas between tradables and nontradables. Relative to the benchmark model, the demand for nontradable goods is much more responsive to a change in the relative price of imported consumption goods. So, after the devaluation, there is a larger expansion in the demand for nontradable goods and employment in the nontradable sector rises by much more than in the benchmark model. This leads to a larger rise in nominal wages.[29] For the reasons discussed above, there is a large incentive for nontradable firms to change prices. Specifically, the percentage change in profits for a deviator rises from 0.27 percent to 1.6 percent of profits. Evidently, a low degree of substitution between nontradable goods and imported goods is important, in our framework, for rationalizing sticky nontradable prices.

Column 6 reports results obtained by increasing the elasticity of demand for exports, γ, from 2.3 to 3.3. This increases the response of exports for two reasons. First, if the fall in $\bar{P}^X/S$ remained the same, we would observe a larger increase in exports in the economy with larger γ. Second, the equilibrium fall in $\bar{P}^X/S$ is actually larger in the economy with larger γ. To see why, note from equation (5.4)

[29] An offsetting effect results from the fact that the theoretical consumption deflator changes by less since the two goods are more substitutable. Other things equal, this leads to a smaller increase in the nominal wage.

that raising γ has the same effect as lowering ϕ^* on the elasticity of $\bar{P}^X/S$ with respect to W/S . For reasons discussed above, $\bar{P}^X/S$ becomes more responsive to the fall in W/S. So the decline in $\bar{P}^X/S$ is larger than in the benchmark model. This, in turn, leads to a larger rise in production and employment in the export sector as well as a larger increase in the nominal wage. The latter effect implies that the benefits from changing prices in the nontradable industry are now larger. Specifically, the gains from deviating rise from 0.27 percent to 3.3 percent of profits. So, to rationalize sticky prices within our model, it is important to have a low elasticity of demand for exports. More generally, as emphasized in our discussion of the model calibration, what is important is that the post-devaluation expansion in exports be modest. The only mechanism to achieve this in our model is to have a low value of γ. At the cost of complicating the model we could embed alternative mechanisms to limit the expansion in exports, e.g. capacity constraints, financing constraints, or frictions to sectoral employment reallocation.

Column 7 summarizes the impact of lowering the share of exports in GDP. In the benchmark model we set this value to 32 percent, which is roughly consistent with pre-crisis data for Korea. The results in column 7 correspond to an export share of 10 percent. This is closer to the export shares in Argentina and Brazil.[30] In our model, a smaller export sector reduces the absolute value of the post-devaluation rise in export sector employment.[31] This, in turn, leads to a smaller rise in nominal wages and a lower incentive for nontradable firms to change prices. Specifically, the percentage change in profits for a deviator falls from 0.27 to 0.15 percent of profits. We conclude that a smaller share of exports in GDP makes the

[30] The pre-devaluation export shares in Argentina and Brazil were 10.9 (in 2000) and 10.6 (in 1998) percent, respectively.

[31] This is consistent with evidence in Gupta, Mishra and Sahay (2001) that suggests that the expansionary effect of a devaluation is stronger when the tradable sector is larger.

sticky price equilibrium easier to generate.

Finally, column 8 reports the impact of lowering the labor supply elasticity from 4 to 1. Relative to the benchmark model, there is a larger rise in the nominal wage and the CPI-deflated real wage. This is a direct consequence of the lower elasticity of labor supply. For reasons discussed above, the higher wage leads to a smaller decline in dollar export prices and a smaller expansion of the export sector. Most importantly, the larger rise in wages increases the benefit to raising prices in the nontradable sector. Specifically, the percentage change in profits rises from 0.27 to 1.6 percent of profits. So we conclude that a high labor supply elasticity is important in our framework for rationalizing sticky nontradable good prices.[32]

8. Conclusion

This paper argued that the primary force behind the large fall in real exchange rates that occurs after large devaluations is slow adjustment in the price of *non-tradable* goods and services. It is not the failure of relative PPP for goods that are actually traded. We then displayed an open economy general equilibrium model that can account for the large fall in real exchange rates that occur in the aftermath if a large devaluation. The key feature of the model is that it embodies forces that mute wage pressures in the wake of the devaluation.

We conclude by briefly highlighting an important shortcoming of our paper. To simplify our analysis, we focused on rationalizing a post devaluation equilibrium in which nontradable good prices did not change at all. In reality, these prices

[32] Recall from Section 3 that, given our assumptions on momentary utility, there are no wealth effects on labor supply. Suppose we had adopted a utility function with the property that labor supply is a decreasing function of wealth (see, for example, King, Plosser, and Rebelo (1988)). Other things equal, labor supply would expand by less in an expansionary devaluation but by more in a contractionary devaluation. So it would be more difficult to rationalize sticky nontradable good prices in the expansionary case but easier to do so in the contractionary case.

do change, albeit by far less than the exchange rate, the price of imports and exportables, or the retail price of tradable goods. Modeling the detailed dynamics of nontradable good prices is a task that we leave for future research.

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Table 1: Price and Exchange Rate Statistics
Cumulative Percent (log) Change

	Korea - September 97				Mexico - December 94			
	3 months	*6 months*	*12 months*	*24 months*	*3 months*	*6 months*	*12 months*	*24 months*
US$ nominal exchange Rate	49.0	49.3	41.2	27.6	50.2	54.9	80.0	83.3
Trade-weighted nominal exchange rate	46.0	46.1	37.9	31.3	50.5	56.0	80.2	82.8
Import Prices (at the dock)	43.3	35.0	16.5	10.4	41.8	47.6	61.7	74.1
Export Prices (at the dock)	37.9	36.7	22.6	16.0	51.8	54.2	69.6	80.2
Consumer price index	2.6	6.5	6.6	7.4	8.7	26.2	39.5	64.0
Retail price of tradables	3.0	8.0	8.2	10.2	10.0	29.6	45.6	72.1
Nontradable prices	2.1	5.0	5.1	4.8	6.7	21.6	31.6	53.6
CPI-based Real Exchange Rate	-43.5	-39.8	-31.9	-25.7	-42.5	-31.3	-43.2	-24.3

	Brazil - January 1999				Argentina - January 2001			
	3 months	*6 months*	*12 months*	*15 months*	*3 months*	*6 months*	*12 months*	*15 months*
US$ nominal exchange Rate	45.3	38.2	42.5	36.8	86.0	129.2	125.5	112.7
Trade-weighted nominal exchange rate	42.2	33.3	38.0	30.4	85.2	128.9	118.3	108.7
Import Prices (at the dock)	51.1	37.3	39.6	31.3	68.1	111.4	111.3	105.2
Export Prices (at the dock)	37.2	26.5	32.1	29.4	n.a.	n.a.	n.a.	n.a.
Consumer price index	2.8	4.0	8.7	10.1	9.3	26.7	34.4	36.8
Retail price of tradables	4.7	6.1	11.7	13.2	16.7	43.6	53.2	55.5
Nontradable prices	0.7	1.8	5.5	6.7	0.5	4.3	8.8	11.4
CPI-based Real Exchange Rate	-39.3	-29.5	-30.1	-21.8	-77.1	-104.0	-88.6	-78.5

Source: National Statistical Agencies

Table 2: How Much of the Decline in the RER is Due to the Decline in the Price of Tradable Goods ?
(Percent as a Fraction of Change in CPI-based-RER)

	Korea - September 97				**Mexico - December 94**			
	3 months	*6 months*	*12 months*	*24 months*	*3 months*	*6 months*	*12 months*	*24 months*
Retail Prices	97.8	91.6	86.1	77.1	98.7	92.3	86.6	63.4
Producer Prices	89.6	79.0	78.1	79.0	97.7	95.0	91.9	79.0
Export / Import Prices*	14.7	21.3	48.8	44.5	12.0	25.4	40.1	36.1
	Brazil - January 1999				**Argentina - January 2001**			
	3 months	*6 months*	*12 months*	*15 months*	*3 months*	*6 months*	*12 months*	*15 months*
Retail Prices	93.6	93.8	93.9	94.3	89.8	84.1	85.9	86.8
Producer Prices	77.2	75.8	48.1	33.3	73.2	61.5	57.8	58.1
Export / Import Prices*	-4.9	7.3	15.6	18.9	23.1	18.9	20.2	23.6

*Import prices for Argentina, average of import and export prices for all other countries.
Source: National Statistical Agencies

Table 3: Argentina - Disaggregated Price Statistics
Cumulative Percent (log) Change
December 2001 - December 2002

	Price change log percent	**Share in CPI** percent
Exchange Rate	125.5	
Import Prices	111.3	
Producer Prices	78.0	
Consumer Prices	34.4	100.0
Tradables	53.2	53.6
Non-tradables	8.8	46.6
Dissagregated Tradables in CPI		
Imported	83.2	3.0
Exportables	62.6	8.6
Mixed Origin	71.7	5.9
With Imported Inputs	49.6	10.1
With Exportable Inputs	44.8	9.7
Local Goods	41.8	16.2
Dissagregated Non-Tradables in CPI		
Public Services	4.7	
Private Services	14.7	

Source: Indec

Table 4: Airfares in Argentina
Airfares between Buenos Aires & other cities
December 2001-December 2002

	City	**Price change** log percent
Exchange Rate		125.53
Domestic flights to:		
	Mar de Plata	16.77
	Cordoba	28.87
	Mendoza	18.04
International flights to:		
	Montevideo	128.79
	Miami	109.78
	Santiago de Chile	113.04
	Madrid	116.51

Source: Indec

Table 5: Inflation and Market Share of Imports and Exportables

Product Category	***Inflation*** *(log percent)* *Dec 01 - June 02*	***Market Share*** *Imported + Exportables* Oct-02
Beer	32.4	12.7
Bread	33.4	52.7
Cereals	40.3	55.7
Cleaning liquids	50.4	86.2
Coffee	45.1	55.8
Deodorant	50.0	86.4
Detergents for clothes	67.1	66.0
Diapers	83.3	72.4
Dish Detergents	50.1	32.1
Female protection	67.0	85.7
Hamburgers	17.9	0.7
Insect Killer	53.3	77.7
Liquid Juice	50.0	11.5
Mayonnaise	64.5	95.4
Milk	41.9	0.2
Paper Towels	52.4	50.8
Shampoo	47.3	71.4
Soap	46.0	70.1
Soda	31.5	3.9
Toothpaste	67.0	68.3
Yogurt	27.7	4.1

Correlation coefficient: 0.69

Source: CCR, INDEC, and our own survey

Table 6: Frequency of Price Adjustment, Buenos Aires

March 27 - December 24, 2002

	Goods	**Services**
Weekly		
Number of Products	58	10
Median Frequency of Price Adjustment (%)	29.8	0
Median Time between Price Change	4.5	∞
Monthly		
Number of Products	58	10
Median Frequency of Price Adjustment (%)	63.2	0
Median Time between Price Change	1.8	∞

Source: Own supermarket dataset

Table 7: Import Content of Consumption and Investment
(Percent of Consumption and Investment Expenditures)

	Korea 1993	***Mexico 1990***	***Brazil 1999***	***Argentina 1997***
Consumption				
Direct Import content	*4.31*	4.67	2.83 *	4.26
Total Import content	*18.16*	10.87	10.48 *	10.52
Investment				
Direct Import content	*12.43*	15.94	n.a.	14.67
Total Import content	*27.52*	26.17	n.a.	22.6
	Australia 1995	***Canada 1990***	***Chile 1996***	***Denmark 1998***
Consumption				
Direct Import content	7.9	12.11	15.87	12.62
Total Import content	17.09	21.48	29.68	23.16
Investment				
Direct Import content	15.54	22.57	35.51	18.7
Total Import content	26.64	35.22	46.15	34.76
	Finland 1995	***France 1995***	***Germany 1995***	***Greece 1996***
Consumption				
Direct Import content	13.06	10.25	13.29	11.09
Total Import content	24	18.64	19.63	18.53
Investment				
Direct Import content	16.72	11.72	11.14	21.31
Total Import content	34.22	32.89	18.45	36.55
	Italy 1992	***Japan 1995***	***Netherlands 1996***	***Norway 1997***
Consumption				
Direct Import content	6.61	4.42	17.31	16.35
Total Import content	16.2	8.94	29.98	28.75
Investment				
Direct Import content	10.24	2.61	21.37	29.45
Total Import content	21.78	8.26	40.46	45.57
	Spain 1995	***Thailand 1996***	***UK 1998***	***US 1997***
Consumption				
Direct Import content	8.77	7.92 *	12.02	4.74
Total Import content	19.45	20.92 *	20.86	9.07
Investment				
Direct Import content	13.46	n.a.	24.01	10.41
Total Import content	26.18	n.a.	35.08	18.39

* National Accounts data

Source: National Statistical Agencies and OECD

Table 8: Benchmark Calibration, Parameter Values

		Parameter value
World real interest rate, percent	6	$r = 0.06$
Share of traded goods in CPI (inclusive of distribution costs), percent	25	$\nu = 0.15$
Domestic distribution margin, percent	50	$\phi = 1$
Foreign distribution margin	50	$\phi^* = 0.41$
Elasticity of demand for exports	2.3	$\gamma = 2.3$
Share of exports in GDP, percent	32	$A^X = 15.43$ $a_0 = -7.42$
Nontradable aggregator parameters		
Pre-devaluation markup	20	$\varepsilon^L = 3$ $\varepsilon^H = 9$ $\bar{z} = 0.0001$
Preference parameters		
Elasticity of labor supply	4	$\theta = 0.25$
Elasticity of subst. in consumpt. between tradables and nontradables	0.1	$\rho = 0.1$
Level parameter, disutility of labor		*B=0.66*
Change in exchange rate, log percent	40.6	

Table 9: Results for Benchmark Model

	Expansionary		Contractionary	
	Flexible Prices	Sticky Prices	Flexible Prices	Sticky Prices
Prices (log percent change)				
Exchange rate	40.5	40.5	40.5	40.5
Export price	40.6	33.8	36.1	33.1
Consumer price index	40.6	6.1	22.4	6.1
Retail price of imported good	40.6	22.3	30.6	22.3
Nontradable price	40.6	0.0	19.5	0.0
Nominal wage	40.6	7.3	19.5	3.3
Quantity (log percent change)				
Total employment	0.0	5.0	-11.0	-10.4
Export employment	0.0	7.6	5.1	8.4
Nontradable employment	0.0	4.8	-12.3	-11.9
Consumption of imported goods	0.0	2.9	-13.3	-13.8
Consumption expenditures / CPI	0.0	4.5	-12.4	-12.2
Incentives to Change Prices (levels)				
Post-devaluation markup, stayers	n.a.	11.5	n.a.	16.1
Optimal markup for deviator	n.a.	12.5	n.a.	16.1
Percentage change in deviator profits	n.a.	0.3	n.a.	0.0

Table 10: Incentives for Nontradable Producers to Deviate from Symmetric Equilibrium for Different Demand Aggregators

	Kimball, Chari-Kehoe-McGrattan	Bergin-Feenstra	Dixit-Stiglitz
Contractionary Devaluation (40.6 percent)	0.00	0.51	1.87
Expansionary Devaluation (40.6 percent)	0.28	7.53	11.10
Expansionary Devaluation (17 percent)	0.00	0.28	1.39

Table 11: The Role of Different Margins in the Model

	1 Benchmark Expansionary	2 Foreign Distribution Margin = 0%	3 Share of Traded Goods in CPI (incl. distribution)	4 No Domestic Distribution
Prices (log percent change)				
Exchange rate	17.0	17.0	17.0	17.0
Export price (in domestic currency)	13.9	9.4	14.3	14.4
Consumer price index	2.3	2.3	4.5	4.5
Retail price of imported good	8.9	8.9	8.9	17.0
Nontradable price	0.0	0.0	0.0	0.0
Nominal wage	2.9	9.4	4.8	5.1
	-1.0	-1.0	-1.0	-1.0
Quantity (log percent change)	-1.0	-1.0	-1.0	-1.0
Total employment	2.3	27.1	1.3	2.3
Export employment	3.5	17.4	3.1	3.0
Nontradable employment	2.2	30.0	1.1	2.2
Consumption of imported goods	1.4	29.2	0.5	0.5
Consumption expenditures / CPI	2.1	29.9	1.0	1.8
	-1.0	-1.0	-1.0	-1.0
Incentives to Change Prices (levels)	-1.0	-1.0	-1.0	-1.0
Post-devaluation markup, stayers	16.6	9.3	14.3	14.0
Optimal markup for deviator (Bergin-Feenstra)	18.0	18.0	18.0	18.0
Percentage change in deviator profits (Bergin-Feenstra)	0.3	15.9	2.1	2.5

	5 $\rho = 1$	6 Elasticity of Demand for Exports = 3.3	7 Share of Exports in GDP = 10%	8 Labor Supply Elasticity = 1
Prices (log percent change)				
Exchange rate	17.0	17.0	17.0	17.0
Export price (in domestic currency)	14.2	10.7	13.9	14.2
Consumer price index	2.3	2.3	2.3	2.3
Retail price of imported good	8.9	8.9	8.9	8.9
Nontradable price	0.0	0.0	0.0	0.0
Nominal wage	4.4	5.6	2.6	4.4
	-1.0	-1.0	-1.0	-1.0
Quantity (log percent change)	-1.0	-1.0	-1.0	-1.0
Total employment	8.5	12.6	1.1	2.1
Export employment	3.2	10.2	3.6	3.2
Nontradable employment	8.9	13.2	1.1	2.0
Consumption of imported goods	1.3	12.4	0.3	1.3
Consumption expenditures / CPI	7.9	13.1	1.0	1.9
	-1.0	-1.0	-1.0	-1.0
Incentives to Change Prices (levels)	-1.0	-1.0	-1.0	-1.0
Post-devaluation markup, stayers	14.8	13.5	16.9	14.8
Optimal markup for deviator (Bergin-Feenstra)	18.0	18.0	18.0	18.0
Percentage change in deviator profits (Bergin-Feenstra)	1.6	3.3	0.2	1.5