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Real Exchange Rate Volatility and the Price of Nontradable Goods in Economies Prone to Sudden Stops

Movements in relative prices play a large role in economic fluctuations, particularly in emerging economies. Sudden stops in capital movements, for instance, are typically associated with sharp depreciations of the real exchange rate, which in turn can wreak havoc with private sector balance sheets. This raises the question of what is behind these real exchange rate fluctuations—whether it is the relative prices of traded goods that move, or the price of nontradables in terms of tradables. Answering this empirical question is crucial both for building relevant models and for designing policies to moderate the dramatic macroeconomic fluctuations that seem to plague emerging economies.

The dominant view in the empirical literature on real exchange rates is that exchange-rate-adjusted relative prices of tradable goods account for most of the observed high variability of consumer-price-index-based real exchange rates.[1] Based on an application of his earlier variance analysis to Mexican data, Engel concludes that this dominant view applies to Mexico.[2] Using a sample of monthly data from 1991 to 1999, he finds that the fraction of the variance of the peso-dollar real exchange rate accounted for by the variance

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1. See the classic article by Engel (1999) and earlier work by Rogers and Jenkins (1995).
2. Engel (1999, 2000).

of the Mexico-U.S. ratio of prices of tradable goods adjusted by the nominal exchange rate exceeds 90 percent, regardless of the time horizon over which the data are differenced.

Engel's finding raises serious questions about the empirical relevance of a large literature that emphasizes the price of nontradables as a key factor for explaining real exchange rates and economic fluctuations in emerging economies. Many papers on noncredible exchange-rate-based stabilizations model the real exchange rate as a positive, monotonic function of the relative price of nontradables (with the latter determined at equilibrium by the optimality conditions for sectoral allocation of consumption and production).[3] Lack of credibility in a currency peg leads to a temporary increase in tradables consumption and a rise in the relative price of nontradables, which causes a temporary real appreciation of the currency. The literature on sudden stops in emerging economies emphasizes the phenomenon of liability dollarization: debts in emerging economies are generally denominated in units of tradable goods or in hard currencies, but they are partially leveraged on the incomes and assets of the large nontradables sector typical of these economies. With liability dollarization, the real exchange rate may collapse in the face of a sharp decline in the price of nontradables, thereby triggering a financial crash and deep recession. For example, Calvo shows how a sudden loss of access to the world credit market can trigger a real depreciation of the currency and systemic bankruptcies in the nontradables sector.[4] The real depreciation occurs because the market price of nontradables collapses when the lack of credit forces a reduction of tradables consumption, while the supply of nontradables remains unaltered.

Engel's finding that nontradables prices account for only a negligible fraction of real exchange rate variability in emerging economies like Mexico undermines the empirical foundation of these theories on sudden stops and the real effects of exchange-rate-based stabilizations. Moreover, it renders irrelevant the key policy lessons derived from these theories on how to cope with the adverse effects of noncredible stabilization policies or to prevent sudden stops. An example of such policies is the push to reduce liability dollarization by developing new foreign debt instruments—either by indexing debt to output or commodity prices or by issuing debt at longer maturities or in domestic currencies. In short: determining the main sources of the observed fluctuations of real exchange rates in emerging economies is a central issue for theory and policy.

3. See Calvo and Végh (1999) for a survey of the studies.
4. Calvo (1998).

A closer look at the empirical evidence suggests, however, that the relative price of nontradables may not be as irrelevant as Engel's work suggests. Mendoza and Uribe report large variations in Mexico's relative price of nontradables during the country's exchange-rate-based stabilization of 1988–94.[5] They do not conduct Engel's variance analysis, so while they show that the price of nontradables rose sharply, their findings cannot establish whether the movement in the nontradables price was important for the large real appreciation of the Mexican peso. Nevertheless, their results point to a potential problem with Engel's analysis of Mexican data—namely, that it does not separate periods of managed exchange rates from periods of floating exchange rates.

A related point is that liability dollarization does seem to matter for emerging market crises. Panel data evidence shows that the relative nontradables price is, in fact, closely linked to the real exchange rate, and it is also systematically related to the occurrence of sudden stops.[6]

This paper has two objectives. The first is to conduct a variance analysis to determine the contribution of fluctuations in domestic prices of nontradable goods relative to tradable goods, vis-à-vis fluctuations in exchange-rate-adjusted relative prices of tradable goods, for explaining the variability of the real exchange rate of the Mexican peso against the U.S. dollar. The results show that Mexico's nontradables prices display high variability and account for a significant fraction of real exchange rate variability in periods of managed exchange rates. In light of these results, the second objective of the paper is to show that a financial accelerator mechanism at work in economies with liability dollarization and credit constraints produces amplification and asymmetry in the responses of the price of nontradables, the real exchange rate, consumption, and the current account to exogenous shocks. In particular, the model predicts that sudden policy-induced changes in relative prices, analogous to those induced by the collapse of managed exchange rate regimes, can set in motion this financial accelerator mechanism. Economies with managed exchange rates can thus display high real exchange rate volatility driven by the relative price of nontradables, because of the effects of liability dollarization in credit-constrained economies.

The variance analysis is based on a sample of monthly data for the 1969–2000 period. The results replicate Engel's findings for a subsample that

5. Mendoza and Uribe (2000).

6. See Calvo, Izquierdo, and Loo-Kung (2006), as well as the analysis of credit booms in IMF (2004, chap. 4).

matches his sample.[7] The same holds for the full sample and for all subsample periods in which Mexico did not follow an explicit policy of exchange rate management. The results are markedly different in periods in which Mexico managed its exchange rate, including episodes with a fixed exchange rate or crawling pegs. In these episodes, the fraction of real exchange rate variability accounted for by movements of tradable goods prices and the nominal exchange rate falls sharply and varies widely with the time horizon of the variance ratios.

Movements in Mexico's relative nontradables prices can account for up to 70 percent of the variance of the real exchange rate. In short, whenever Mexico managed its exchange rate, the country experienced high real exchange rate variability, but movements in the price of nontradable goods contributed significantly to explaining it.

The Mexican data also fail to reproduce two other key findings of Engel's work. In addition to the overwhelming role of tradable goods prices in explaining real exchange rates, Engel finds, first, that covariances across domestic relative nontradables prices and cross-country relative tradables prices tend to be generally positive or negligible and, second, that variance ratios corrected to take these covariances into account generally do not change results derived using approximate variance ratios that ignore them. Contrary to these findings, the correlation between domestic relative nontradables prices and international relative tradables prices is sharply negative in periods in which Mexico had a managed exchange rate. The standard deviation of Mexico's domestic relative prices is also markedly higher during these periods. As a result, measures of the contribution of tradable goods prices to real exchange rate variability that are corrected to take these features of the data into account are significantly lower than those that do not.

Recent cross-country empirical studies provide further time-series and cross-sectional evidence indicating that the relative price of nontradables explains a significantly higher fraction of real exchange rate variability under managed exchange rates than under more flexible arrangements. Naknoi constructs a large data set covering thirty-five countries and nearly 600 pairs of bilateral real exchange rates.[8] She finds that Engel's result holds for many of these pairs, but she also finds many cases for which it does not, including some in which the relative price of nontradables accounts for about 50 percent of real exchange rate variability. She also reports that the variability of

7. Engel (2000).
8. Naknoi (2005).

the relative price of nontradables rises as that of the nominal exchange rate falls; in some cases, it exceeds the variability of exchange-rate-adjusted relative prices of tradable goods. Parsley examines the cross-paired and U.S.-dollar-based real exchange rates of six countries of Southeast Asia using monthly data.[9] He finds that in subsamples with managed exchange rates for Hong Kong, Malaysia, and Thailand, the relative price of nontradables could explain up to 50 percent of the real exchange rate variability. All these findings are related to the works of Mussa and of Baxter and Stockman, which show that the variability of the real exchange rate is higher under flexible exchange rate regimes than under managed exchange rate regimes, although they do not decompose this variability in terms of the contributions of the relative prices of tradables versus nontradables.[10]

A common approach followed in the international macroeconomics literature is to take the above empirical evidence as an indication of the existence of nominal rigidities affecting price or wage setting. This approach is the focus of extensive research examining the interaction of nominal rigidities with alternative pricing arrangements (such as pricing to market and local versus foreign currency invoicing) and with different industrial organization arrangements (such as endogenous tradability). Unfortunately, the ability of these models to explain the variability of real exchange rates, even among country pairs for which the dominant view holds, is limited. Chari, Kehoe, and McGrattan find that models with nominal rigidities cannot explain the variability of real exchange rates in industrial countries unless the models adopt separable preferences in leisure and values that are at odds with empirical evidence for the coefficients of relative risk aversion and capital adjustment costs and for the periodicity of staggered price adjustments.[11] Moreover, the conclusion that nominal rigidities must be at work does not follow from the observation that under managed exchange rates the behavior of the real exchange rate is more closely linked to that of the price of nontradables. Theoretical analysis shows that the equilibria obtained for monetary economies under alternative exchange rate regimes, with or without nominal rigidities, can be reproduced in monetary economies with flexible prices with appropriate combinations of tax-equivalent distortions on consumption and factor incomes.[12]

9. Parsley (2003).
10. Mussa (1986); Baxter and Stockman (1989).
11. Chari, Kehoe, and McGrattan (2002).
12. See Adão, Correia, and Teles (2005); Coleman (1996); Mendoza (2001); Mendoza and Uribe (2000).

Instead of emphasizing the role of nominal rigidities, this paper uses a simple nonmonetary model of endogenous credit constraints with liability dollarization to illustrate how a strong amplification mechanism driven by a variant of Fisher's debt-deflation process can induce high variability in the nontradables price and the real exchange rate in response to exogenous shocks. In particular, policy-induced shocks to relative prices akin to those triggered by a currency devaluation can set in motion this amplification mechanism. The financial accelerator that amplifies the responses of consumption, the current account, and the price of nontradables to shocks of usual magnitudes combines a standard balance sheet effect (because of the mismatch between the units in which debt is denominated and the units in which some of this debt is leveraged) with Fisher's debt-deflation process: an initial fall in the price of nontradables triggered by an exogenous shock tightens further credit constraints, leading to a downward spiral in access to debt and the price of nontradables.

A set of basic numerical experiments suggests that the quantitative implications of this financial accelerator are significant. Fisher's debt-deflation process is a powerful vehicle for inducing amplification and asymmetry in the economy's responses to exogenous shocks (particularly to changes in taxes that approximate the relative price effects of changes in the rate of currency devaluation). The magnitude of the effects that Fisher's deflation has on the nontradables price, the real exchange rate, and the current account dwarf those that result from the standard balance sheet effect that is widely studied in the sudden stop literature. In this way, the model can simultaneously account for high variability of the real exchange rate and key features of the sudden stop phenomenon as the result of (endogenous) high variability of the relative price of nontradables.

The model is analogous to the models with liquidity-constrained consumers of the closed-economy macroeconomic literature and to the dynamic, stochastic general equilibrium models reviewed by Arellano and Mendoza.[13] The setup provided in this paper is simpler in order to focus the analysis on the amplification mechanism linking sudden stops and real exchange rate movements driven by the relative price of nontradables.

The rest of the paper is organized as follows. The next section conducts the variance analysis of the Mexico-U.S. real exchange rate. The paper then develops the model of liability dollarization with financial frictions in which "excess volatility" of the real exchange rate is caused by fluctuations in the relative

13. Arellano and Mendoza (2003).

price of nontradables. The closing section presents conclusions and policy implications.

Variance Analysis of the Peso-Dollar Real Exchange Rate

This section presents the results of a variance analysis that closely follows the methodology applied by Engel.[14] The analysis uses non-seasonally-adjusted monthly observations of the consumer price index (CPI) and some of its components for Mexico (*MX*) and the United States (*US*) over the period January 1969 to February 2000. Mexican data are from the Bank of Mexico's web site; those for the United States are from the Bureau of Labor Statistics.[15] Data for three price indexes were collected for each country: the aggregate CPI (P^i for $i = MX, US$), the consumer price indexes for durable goods (PD^i for $i = MX, US$), and the one for services (PS^i for $i = MX, US$). The data set also includes the nominal exchange rate series for the monthly average exchange rate of Mexican pesos per U.S. dollar (E), as reported by the International Monetary Fund (IMF) in its *International Financial Statistics.* The real exchange rate was generated following the IMF convention: $RER = P^{MX} / (EP^{US})$. The data were transformed into logs, with logged variables written in lowercase letters.

Durable goods are treated as tradable goods, and services are treated as nontradable goods. This definition is in line with standard treatment in empirical studies of real exchange rates. It is also roughly consistent with a sectoral classification of Mexican data based on a definition of tradable goods as pertaining to sectors in which the ratio of total trade to gross output exceeds 5 percent.[16]

Simple algebraic manipulation of the definition of the real exchange rate yields this expression: $rer_t = x_t + y_t$.[17] The variable x_t is the log of the exchange-rate-adjusted price ratio of tradables across Mexico and the United States: $x_t = pd_t^{MX} - e_t - pd_t^{US}$. (This is the negative of Engel's measure because the real exchange rate is defined here using the IMF's definition.) If the strong assumptions needed for the law of one price to hold in this context were satisfied, x_t should be a constant that does not contribute to explaining variations in rer_t. The variable y_t includes the terms that reflect domestic prices of non-

14. Engel (1999, 2000).
15. Bank of Mexico (www.banxico.org.mx); U.S. Bureau of Labor Statistics (stats.bls.gov).
16. See Mendoza and Uribe (2000).
17. See Engel (2000).

tradables relative to tradables in each country: $y_t = b_t^{MX}(ps_t^{MX} - pd_t^{MX}) - b_t^{US}(ps_t^{US} - pd_t^{US})$, where b_t^{MX} and b_t^{US} are the (potentially time-varying) weights of nontradables in each country's CPI. The logs of the relative prices of nontradables are therefore $pn_t^{MX} \equiv ps_t^{MX} - pd_t^{MX}$ and $pn_t^{US} \equiv ps_t^{US} - pd_t^{US}$.

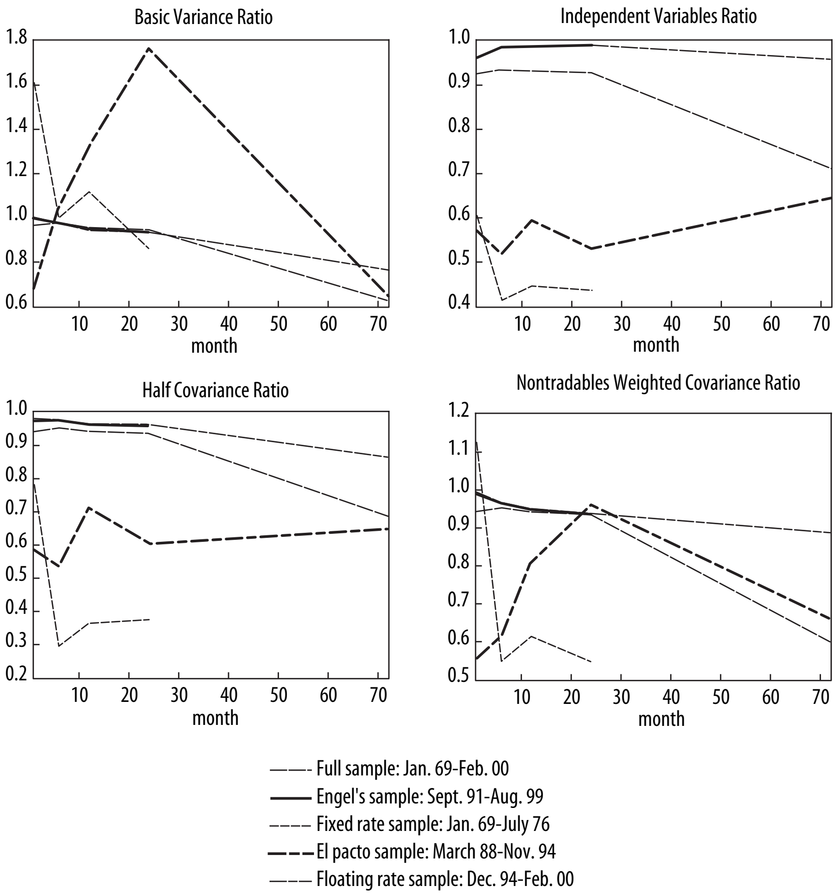
Figure 1 summarizes the results of the variance analysis of the peso-dollar real exchange rate. The figure is based on an earlier paper, which reports detailed results not only for the variance ratios for the real exchange rate, but also for the standard deviations and correlations of *rer, y, x,* pn^{MX}, and pn^{US}.[18] As argued below, changes in these moments are useful for explaining the changes in the results of the variance analysis across fixed and floating exchange rate regimes. The discussion of the results below refers to the changes in the relevant moments, although the earlier paper provides the complete set of moments.

Each panel in figure 1 shows curves for five different sample periods: the full sample; the sample studied by Engel, which he retrieved from *Datastream* for the period September 1991 to August 1999; a sample that includes only data for the post-1994 floating exchange rate; a fixed exchange rate sample covering January 1969 to July 1976; and a sample covering the managed exchange rate regime that anchored the stabilization plan known as *El Pacto* (March 1988 to November 1994).[19] This last sample includes an initial one-year period with a fixed exchange rate followed by a crawling peg within a narrow band (the boundaries of which were revised occasionally).

Each of the four panels shows results for an alternative measure of the variance ratio that quantifies the fraction of real exchange rate variability explained by x_t (that is, the relative price of tradables). The ratios are plotted as functions of the time frequency over which the data were differenced (one month, six months, twelve months, twenty-four months, and, for samples with sufficient observations, seventy-two months). The plots show results for four variance ratios. The first is Engel's basic ratio, $\sigma^2(x) / \sigma^2(rer)$.[20] In general, $\sigma^2(rer) = \sigma^2(x) + \sigma^2(y) + 2\ \text{cov}(x, y)$, where $\text{cov}(x, y)$ is the covariance between x and y, so this basic ratio is accurate only when x and y are independent random variables—that is, when $\text{cov}(x, y) = 0$. Engel therefore computes the following second and third ratios as alternatives that adjust for covariance terms.[21]

18. Mendoza (2000, table 1).
19. The second sample follows Engel (2000).
20. Engel (2000).
21. Engel (1995).

FIGURE 1. Fraction of Mexico's Real Exchange Rate Variability Explained by Tradable Goods Prices at Different Time Frequencies



The second ratio, then, is referred to as the independent variables ratio, $\sigma^2(x) / [\sigma^2(rer) - \text{cov}(x, y)]$, which deducts from the variance of *rer* in the denominator of the variance ratio the effect of cov(*x, y*). The third is labeled the half covariance ratio, $[\sigma^2(x) + \text{cov}(x, y)] / \sigma^2(rer)$, which measures the contribution of *x* to the variability of *rer* by assigning to *x* half of the effect of cov(*x, y*) on the variance of *rer.* This half covariance ratio can be written as the product of the basic ratio multiplied by $1 + \rho(x, y) [\sigma(y) / \sigma(x)]$, where $\rho(x, y)$ is the correlation between *x* and *y*. Consequently, the basic ratio approximates well the half covariance ratio if $\rho(x, y)$ is low or the standard deviation of x is large relative to that of y (or both). Finally, a fourth ratio is the nontradables weighted covariance ratio, which controls only for the covariance between x and the domestic relative price of nontradables in Mexico by rewriting the variance ratio as $[\sigma^2(x) / \sigma^2(rer)]\ \{1 + \rho(x, pn^{MX})\ [b^{MX}\sigma(pn^{MX}) / \sigma(x)]\}$. The basic ratio accurately approximates this fourth variance ratio when the correlation between x and pn^{MX} is low or the standard deviation of x is large relative to that of pn^{MX} (or both).

The motivation for the fourth ratio follows from the fact that while the half covariance ratio aims to correct for the variance of *rer* that is due to the covariance of x and y, it is silent about the contributions of the various elements that make up y itself. The latter can be important because y captures the combined changes in domestic relative prices of nontradables in Mexico and the United States, as well as the recurrent revisions to the weights used in each country's CPI (which take place at different intervals in each country). Moreover, since the aggregate CPIs include nondurables, in addition to durables and services, y also captures the effects of cross-country differences in the prices of nondurables relative to durables. Computing an exact variance ratio that decomposes all of these effects requires controlling for the full variance-covariance matrix of y, x, pn^{MX}, pn^{US}, b^{MX} and b^{N}. Since data to calculate this matrix are not available, the nontradables weighted covariance ratio is used as a proxy that isolates the effect of the covariance between pn^{MX} and *rer.* The complement (that is, 1 minus the fourth variance ratio) is a good measure of the contribution of Mexico's relative price of nontradables to the variance of the real exchange rate to the extent that movements in the CPI weights play a minor role and the correlation between pn^{MX} and pn^{US} is low or the variance of pn^{MX} largely exceeds that of pn^{US}.[22]

The potential importance of covariance terms in the calculation of a variance ratio, and hence the need to consider alternative definitions of this ratio, is a classic problem in variance analysis. Engel considers this issue carefully in his work on industrial country real exchange rates and on the peso-dollar real exchange rate, and he concludes that it could be set aside safely. As shown below, however, the features of the data that support this conclusion are not present in the data for Mexico's managed exchange rates. The variance ratios that control for covariance effects therefore play a crucial role in this case. Engel argues that in the case of the components of the real exchange rate of

22. Computing this variance ratio requires an estimate for a constant value of b^{MX}, which was determined using 1994 weights from the Mexican CPI, extracted from a methodological note provided by the Bank of Mexico ($b^{MX} = 0.6$).

the United States vis-à-vis industrial countries, "comovements between x and y are insignificant in all cases, except when we use the aggregate PPI [producer price index] as the traded goods price index."[23] Engel later notes that the basic ratio "tends to underestimate the importance of x as long as the covariance term (between x and y) is positive (which it is at most short horizons), but any alternative treatment of the covariance has very little effect on the measured relative importance of the x component."[24] Under these conditions, the basic ratio either is very accurate—if $\rho(x, y)$ is low—or, in the worst-case scenario, represents a lower bound for the true variance ratio—if $\rho(x, y)$ is positive. In either case, a high ratio $\sigma^2(x) / \sigma^2(rer)$ indicates correctly that real exchange rate fluctuations are mostly explained by movements in tradable goods prices and in the nominal exchange rate.

The results shown in the four panels of figure 1 for the full sample period are firmly in line with Engel's findings, except in the very long horizon of seventy-two months. At frequencies of twenty-four months or less, the basic ratio always exceeds 0.94, and using any of the other ratios to correct for covariances across x and y, or across x and pn^{MX}, makes no difference. These results reflect the facts that for the full sample, the correlations between x and y and between x and pn^{MX} are always close to zero, and the standard deviation of x is 3.5 to 3.7 times larger than that of y and 2.9 to 3.7 times larger than that of pn^{MX}.[25] Covariances of x with pn^{US} are also irrelevant because the correlations between these variables are generally negligible and the standard deviations of pn^{US} are all small. The correlations between pn^{MX} and pn^{US} are also negligible.

A very similar picture emerges for Engel's sample and for the post-1994 floating period.[26] The one notable difference is that frequencies higher than one month display marked negative correlations between x and pn^{US} and between pn^{MX} and pn^{US}. These correlations could, in principle, add to the contribution of domestic relative price variations in explaining the variance of rer. They can be safely ignored, however, because the standard deviation of x dwarfs those of pn^{US} and pn^{MX} at all time horizons, and the latter still have to be reduced by the fractions b^{MX} and b^{US}, respectively. In summary, in periods in which the Mexican peso is floating, the variability of exchange-rate-adjusted tradable goods prices is so much larger than that of relative non-tradables prices that covariance adjustments cannot alter the result that the

23. Engel (1995, p. 31).
24. Engel (2000, p. 9).
25. See Mendoza (2000, table 1) for details.
26. Engel (2000).

relative price of nontradables is of little consequence for movements in the real exchange rate.

The picture that emerges from Mexico's managed exchange rate regimes is very different. For both the fixed rate sample and the sample for *El Pacto,* the basic ratio is very high and often exceeds 1, indicating the presence of large covariance terms. The other three variance ratios show dramatic reductions in the share of real exchange rate variability attributable to x compared with the results for periods without exchange rate management. For instance, the half covariance ratio for the fixed exchange rate sample shows that the contribution of x to the variability of the real exchange rate reaches a minimum of 0.29 at the six-month frequency and remains low at around 0.36 at the twelve- and twenty-four-month frequencies. The nontradables weighted ratio, which corrects for the covariance between x and pn^{MX}, is below 0.61 at frequencies higher than one month. In the sample for *El Pacto,* the independent variables and half covariance ratios indicate that the contribution of x to the variability of the real exchange rate is below 0.60 at all frequencies (except for the half covariance ratio at the twelve-month frequency, in which case it increases to 0.70). Using the nontradables weighted ratio and considering only the covariance between x and pn^{MX}, the variance of *rer* attributable to x reaches a lower bound of 0.55 at the one-month frequency (although it increases sharply at the twenty-four-month frequency before declining again at the seventy-two-month frequency).

These striking differences in the outcome of the variance analysis for periods of exchange rate management reflect two critical changes. First, the standard deviations of the Mexican relative price of nontradables and the composite variable y increase significantly relative to the standard deviations of x; the ratios of the standard deviation of x to that of y now range between 0.7 and 1.2. Second, the correlations between x and y and between x and pn^{MX} fall sharply and become markedly negative (approaching −0.6 in most cases).

Comparing periods of managed and floating exchange rates reveals two additional features. First, the correlation between x and *rer* is much lower in the former than in the latter: the correlation between x and *rer* is almost 1.00 at all time horizons in periods of floating exchange rates, while it ranges between 0.29 and 0.70 in the samples of managed exchange rates. Second, some of the managed exchange rate scenarios, particularly the twelve- and twenty-four-month horizons of the *El Pacto* sample, yield a positive correlation between the relative prices of nontradable goods in Mexico and the United States, which can be as high as 0.32. This second result actually reduces the share of fluctuations in *rer* that can be accounted for by y. Because the U.S. and Mexican relative prices of nontradable goods are likely to increase together, differences in these domestic relative prices across countries tend to offset each other, and hence they are not highly important for real exchange rate fluctuations.

The only feature of the statistical moments of the data examined here that is robust to changes in the exchange rate regime is the fact that the variability of relative nontradables prices in Mexico always exceeds that of the United States by a large margin. For the full (*El Pacto*) sample, the ratio of the standard deviation of pn^{MX} to that of pn^{US} ranges from 3.7 (3.4) at the one-month frequency to 4.9 (7.1) at the twenty-four-month frequency. However, Mexico's relative nontradables prices tend to be more volatile under a currency peg than a float. The ratio of the standard deviation of pn^{MX} for the *El Pacto* sample to that for the post-1994 floating period doubles from 1 at the one-month frequency to about 2 at the twenty-four-month frequency. The higher volatility of the relative price of nontradables in Mexico than in the United States, and under a managed versus a floating exchange rate regime, is a significant feature of the data that helps explain why the nontradables price accounts for a nontrivial fraction of the variability of Mexico's real exchange rate in periods of exchange rate management.

Sudden Stops and Nontradables-Driven Real Exchange Rate Volatility

The previous section showed that in periods in which Mexico managed its exchange rate, the relative nontradables price accounted for a significant fraction of the high variability of the real exchange rate. This evidence raises the question of whether analysts should be concerned about volatility of the real exchange rate driven by nontradable goods prices. This section argues that this issue is, in fact, a concern. The main argument is that in economies that suffer from liability dollarization, the sudden stop phenomenon and the high variability of the real exchange rate may both be the result of high volatility in nontradables prices. To support this argument, the section examines a simple model in which endogenous credit constraints and liability dollarization produce a financial accelerator mechanism that amplifies the responses of consumption, the current account, the price of nontradables, and the real exchange rate to exogenous shocks.

Credit frictions and liability dollarization are widely studied in the sudden stop literature. The goal here is to provide a basic framework that highlights how balance sheet effects and Fisher's deflation process interact to trigger high volatility of the real exchange rate and sudden stops. The mechanism is similar to those explored by Arellano and Mendoza.[27]

Consider a conventional nonstochastic intertemporal equilibrium setup of a two-sector, representative-agent, small open economy with endowments of tradables (y_t^T) and nontradables (y_t^N). The households in this economy solve the following problem:

(1) $$\max_{\left[c_t^T, c_t^{Ts}, b_{t+1}\right]_0^\infty} \sum_{t=0}^{\infty} \beta^t u\left(c\left(c_t^T, c_t^N\right)\right),$$

subject to:

(2) $$c_t^T + \left(1 + \tau_t\right) p_t^N c_t^N = y_t^T + p_t^N y_t^N - b_{t+1} + b_t R + T_t \text{ and}$$

(3) $$b_{t+1} \geq -\kappa\left(y_t^T + p_t^N y_t^N\right) \geq -\Omega.$$

Utility is defined in terms of a composite good, c, that depends on consumption of tradables (c_t^T) and nontradables (c_t^N). This composite good takes the form of a standard constant elasticity of substitution (CES) function, and the utility function, $u(\cdot)$, is a standard increasing, twice continuously differentiable, and concave utility function. Since c is a CES aggregator, the marginal rate of substitution between nontradables and tradables satisfies

$$\frac{c_2\left(c_t^T, c_t^N\right)}{c_1\left(c_t^T, c_t^N\right)} = \Phi\left(\frac{c_t^T}{c_t^N}\right),$$

where Φ is an increasing, strictly convex function of the ratio c_t^T/c_t^N. The price of tradables is determined in competitive world markets and normalized to unity without loss of generality; p_t^N denotes the price of nontradable goods relative to tradables.

As is evident from the budget constraint in equation 2, international debt contracts are denominated in units of tradable goods, so this economy features liability dollarization. The only asset traded with the rest of the world is a one-period bond that pays a constant gross real interest rate of R, in units of tradables.

27. Arellano and Mendoza (2003); Mendoza (2002).

World credit markets are imperfect. In particular, constraint 3 states that foreign creditors limit their lending to the small open economy so as to satisfy a liquidity constraint up to a debt ceiling. The liquidity constraint limits debt to a fraction, κ, of the value of the economy's current income in units of tradables. The debt ceiling requires that the debt allowed by the liquidity constraint not exceed a maximum level, Ω. This maximum debt helps rule out perverse equilibria in which agents could satisfy the liquidity constraint by running very large debts to finance high levels of tradables consumption and prop up the price of nontradables.

The above credit constraints can result from informational frictions or institutional weaknesses affecting credit relationships (such as monitoring costs, limited enforcement, and costly information). For simplicity, the contracting environment that yields the constraints is not part of the model, but rather the credit constraints are taken as given to focus on their implications for equilibrium allocations and prices. Setting credit limits in terms of the debt-income ratio, as in equation 3, is common practice in actual credit markets, particularly in household mortgage and consumer loans.

The government imposes a tax, τ_t, on private consumption of nontradable goods. This approximates some of the effects that a change in the currency's depreciation rate would have in a monetary model in which money economizes transaction costs or enters in the utility function.[28] The government also maintains time-invariant levels of unproductive government expenditures in tradables and nontradables ($\bar{g}^T$ and $\bar{g}^N$, respectively), and it is assumed to run a balanced budget policy for simplicity. Hence, any movements in the primary fiscal balance stemming from either exogenous policy changes in the tax rate or endogenous movements in the price of nontradables are offset via lump-sum rebates or taxes, T_t. The government's budget constraint is therefore

$$(4) \qquad \tau_t p_t^N c_t^N = \bar{g}^T + p_t^N \bar{g}^N + T_t.$$

A competitive equilibrium for this economy is a sequence of allocations $[c_t^T, c_t^N, T_t, b_{t+1}]_0^\infty$ and prices $[p_t^N]_0^\infty$ such that (a) the allocations represent a solution to the households' problem, taking the price of nontradables, the tax rate,

28. See Mendoza (2001). Adão, Correia, and Teles (2005), Coleman (1996), and Mendoza and Uribe (2000) provide other examples in which the equilibria of monetary economies with alternative exchange rate regimes, and with or without nominal rigidities, can be reproduced in nonmonetary economies with appropriate combinations of tax-equivalent distortions.

and government transfers as given; (b) the sequence of transfers satisfies the government budget constraint given the tax policy, government expenditures, private consumption of nontradables, and the relative price of nontradables; and (c) the following market-clearing condition in the nontradables sector holds:

$$c_t^N + \overline{g}^N = y_t^N. \tag{5}$$

Given equations 2, 4, and 5, the resource constraint in the tradables sector is

$$c_t^T + \overline{g}_t = y_t^T - b_{t+1} + Rb_t. \tag{6}$$

In the economy described by equations 1 through 6, the responses of consumption, the current account, the real exchange rate, and the price of nontradables to exogenous shocks exhibit endogenous amplification via a financial accelerator mechanism when the credit constraints bind, This mechanism operates via a balance sheet effect and Fisher's deflation, which are triggered by movements in the relative price of nontradables. Other studies examine the quantitative implications of more sophisticated variants of this model, incorporating uncertainty, incomplete financial markets, and labor demand and supply decisions in the nontradables sector.[29] This paper focuses only on the key aspects of the economic intuition behind the model's financial accelerator.

Equilibrium When the Credit Constraints Never Bind: Perfectly Smooth Consumption

Consider first a scenario in which the credit constraints never bind. In this case, the model yields an equilibrium identical to what would be obtained with perfect credit markets. The economy borrows or lends at the world-determined interest rate with no other limitation than the standard no-Ponzi-game condition, which requires that the present value of tradable goods absorption equals the tradables sector's wealth. The latter is composed of nonfinancial wealth (W_0) and financial wealth (Rb_0), so that the economy faces this intertemporal budget constraint:

$$\sum_{t=0}^{\infty} R^{-t} c_t^T = \sum_{t=0}^{\infty} R^{-t}\left(y_t^T - \overline{g}^T\right) + Rb_0 = W_0 - \left(\frac{R}{R-1}\right)\overline{g}^T + Rb_0. \tag{7}$$

29. See Mendoza (2002).

Next the model adopts a set of assumptions that imply that when the credit frictions never bind, the equilibrium reduces to a textbook case of perfectly smooth consumption. In particular, assume that the economy satisfies the traditional stationarity condition, $\beta R = 1$, and that the nontradables output is time invariant ($y_t^N = \overline{y}^N$ for all t). It follows from equation 5 and the standard Euler equation for tradables consumption that $c_t^T = \overline{c}^T$ for all t. The intertemporal constraint in equation 7 then implies that the equilibrium sequence of tradables consumption is perfectly smooth at this level:

$$(8) \qquad \overline{c}^T = (1-\beta)(W_0 + Rb_0) - \overline{g}^T.$$

The optimality condition that equates the marginal rate of substitution in tradables and nontradables consumption with the after-tax relative price of nontradables further implies that the equilibrium price of nontradables is

$$(9) \quad p_t^N = \overline{p}_t^N = \frac{c_2(\overline{c}^T, \overline{y}^N - \overline{g}^N)}{c_1(\overline{c}^T, \overline{y}^N - \overline{g}^N)}(1+\tau_t)^{-1} = \Phi\left(\frac{\overline{c}^T}{\overline{y}^N - \overline{g}^N}\right)(1+\tau_t)^{-1}.$$

Since tradables consumption is perfectly smooth and both the endowment and government consumption of nontradables are time-invariant by assumption, equation 9 states that any variations in the relative price of nontradables result only from government-induced variations in the tax on nontradables consumption. Tax policy is neutral in the sense that variations in the tax alter the price of nontradables but not consumption allocations or the current account. Thus, if credit constraints never bind, tax-induced real devaluations are neutral (that is, changes in the exchange rate regime make no difference for the behavior of the real exchange rate).

As long as the credit constraints do not bind, the results in equations 8 and 9 hold for any time-varying, deterministic, nonnegative stream of tradables endowments. To compare this perfectly smooth equilibrium with the equilibrium of the economy with binding credit constraints, consider a particular stream of tradables income that provides an incentive for the economy to borrow at date 0. Using standard concepts from the permanent income theory of consumption, define an arbitrary time-varying sequence of tradables endowments as an equivalent sequence with a time-invariant endowment (or permanent income). Hence, the level of nonfinancial wealth in equation 7 satisfies $\overline{y}^T = (1-\beta)W_0$, where $\overline{y}^T$ is the time-invariant tradables endowment that yields the same present value of tradables income (that is, the same wealth) as a given time-varying sequence paid to households. Then define a wealth-neutral shock to tradables income at date 0 as a change in the endowment at date 0 offset by a change in the endowment at date 1, which keeps the present value of the two constant (leaving the rest of the sequence of tradables income in W_0 unchanged). Thus, wealth-neutral shocks to income at date 0 satisfy the following:

$$y_1^T - \bar{y}^T = \beta^{-1}\left(\bar{y}^T - y_0^T\right). \tag{10}$$

Condition 10 states that, if the endowment at date 0 falls below permanent income, the endowment at date 1 increases above permanent income by enough to keep the present value constant. For any $0 < y_0^T < \bar{y}^T < y_1^T$ that satisfies condition 10 and for which the credit constraints do not bind, the economy maintains the perfectly smooth equilibrium with these results:

$$\bar{c}^T = \left(1 - \beta\right)\left(W_0 + Rb_0\right) - \bar{g}^T;$$
$$\bar{p}_t^N = \Phi\left(\frac{\bar{c}^T}{\bar{y}^N - \bar{g}^N}\right)\left(1 + \tau_t\right)^{-1}; \tag{11}$$
$$\bar{b}_1 - b_0 = y_0^T - \bar{y}, \quad \bar{b}_2 - \bar{b}_1 = -\left(\bar{b}_1 - b_0\right), \quad \bar{b}_1 = b_0 \text{ for } t \geq 2.$$

Hence, consumption allocations and the price of nontradables remain at their first-best levels, and the current account deficit at date 0 equals the current account surplus at date 1. The economy thus reduces asset holdings below b_0 at date 0 (that is, the economy borrows) and returns to its initial asset position at date 1. Policy-induced real devaluations of the currency are still neutral with respect to all of these outcomes.

The Economy with Binding Credit Constraints

Now consider unanticipated, wealth-neutral shocks to y_0^T that satisfy condition 10. If the shock to y_0^T is not large enough to trigger the credit constraints, the solutions obtained in equation 11 still hold. The liquidity constraint binds, however, if the shock lowers y_0^T to a point at or below a critical level. This critical level is given by the following:

$$\hat{y}^T = \frac{\bar{y}^T - b_0 - \kappa\bar{p}_0^N\bar{y}^N}{1 + \kappa}. \tag{12}$$

Since only positive endowments are possible, condition 12 also implies an upper bound for κ:

$$\kappa < \kappa^h = \frac{1 - \left(b_0 / \bar{y}^T\right)}{\left(\bar{p}_0^N \bar{y}^N\right) / \bar{y}^T}.$$

If κ exceeds this critical value, the model allows for enough debt so that the liquidity constraint never binds for any positive value of y_0^T. There is also a lower bound for κ, and this is the level at which satisfying the liquidity constraint would make tradables consumption and the nontradables price fall to zero:

$$\kappa < \kappa^l = \frac{\bar{g}^T - \bar{y}_0^T - Rb_0}{y_0^T}.$$

A critical observation about the result in equation 12 is that for a given wealth-neutral pair (y_0^T, y_1^T), a sufficiently large and unanticipated tax increase at date 0 (that is, a policy-induced real depreciation) can also move the economy below the critical level of tradables income. This triggers the credit constraints, because it lowers the price of nontradables and the value of the nontradables endowment. Since this affects the equilibrium outcomes of consumption, the current account, the price of nontradables, and the real exchange rate, a policy-induced real depreciation of the currency is no longer neutral once the credit constraints bind. Now alternative policy regimes yield very different outcomes for real exchange rate behavior.

For simplicity, assume a debt ceiling set at $\Omega = -\bar{b}_1$. Shocks that put y_0^T below its critical level trigger the liquidity constraint, and equilibrium allocations and prices for date 0 are then

$$c_0^T = y_0^T - \bar{g}^T + \kappa\left(y_0^T + p_0^N \bar{y}^N\right) + Rb_0; \tag{13}$$

$$p_0^T = \Phi\left(\frac{c_0^T}{\bar{y}^N - \bar{g}^N}\right)\left(1 + \tau_0\right)^{-1}; \tag{14}$$

$$b_1 - b_0 = -\kappa\left(y_0^T + p_0^N \bar{y}^N\right) - b_0 > \Omega - b_0. \tag{15}$$

Since $b_1 = -\kappa(y_0^T + p_0^N \bar{y}^N) > \bar{b}_1$, it is clearly the case that $c_0^T < \bar{c}^T$, $p_0^N < \bar{p}_0^N$, and $b_1 - b_0 > \bar{b}_1 - b_0$. Thus, when the credit constraint binds, tradables consumption and the price of nontradables are lower than in the perfectly smooth case, whereas the current account is higher. In other words, the economy's response to a shock that puts the tradables endowment below the critical level involves a sudden stop—a drop in tradables consumption, a real depreciation, and a current account reversal.

The above argument is similar to Calvo's: if the country cannot borrow, tradables consumption falls; this lowers the price of nontradables, which validates the country's reduced borrowing ability via a balance sheet effect and the liability dollarization feature of the credit constraint.[30] The difference with Calvo's setup is that the equilibrium characterized by conditions 13 through 15 also features Fisher's debt-deflation mechanism.

Fisher's deflation amplifies the responses of quantities and prices. In particular, tradables consumption and the nontradables price at date 0 are determined by solving the two-equation system formed by equations 13 and 14. Equation 13 shows that tradables consumption depends on the nontradables price when the credit constraint binds because of liability dollarization: changes in the value of the nontradables endowment affect agents' ability to borrow in tradables-denominated debt. Equation 14 shows that the price of nontradables depends on the consumption of tradables via the standard optimality condition for sectoral consumption allocations. Fisher's deflation then occurs because the price of nontradables falls with tradables consumption; this drop in price tightens the credit constraint, which makes tradables consumption fall further, which in turn makes the price of nontradables fall further.

Figure 2 illustrates the determination of the equilibrium at date 0 when Fisher's deflation process is at work. The vertical line, TT, represents the perfectly smooth tradables consumption allocation, which is independent of the price of nontradables. The PP curve represents the optimality condition for sectoral consumption allocations; this condition equates the marginal rate of substitution between tradables and nontradables with the corresponding after-tax relative price (that is, equation 14). Since the consumption aggregator is CES and nontradables consumption is constant at $\overline{y}^N - \overline{g}^N$, PP is an increasing, convex function of tradables consumption. TT and PP intersect at the equilibrium price of the perfectly smooth consumption case (point A).

The SS line represents equation 13, which is the tradables resource constraint when the liquidity constraint binds. SS is an upward-sloping, linear function of tradables consumption, with a slope of $1/\kappa\,\overline{y}^N$. Since the horizontal intercept of SS is $Rb_0 - \overline{g}^T + (1 + \kappa)y_0^T$, SS shifts to the left as y_0^T falls. In

30. Calvo (1998).

FIGURE 2. Equilibrium in the Nontradables Market with Fisherian Deflation

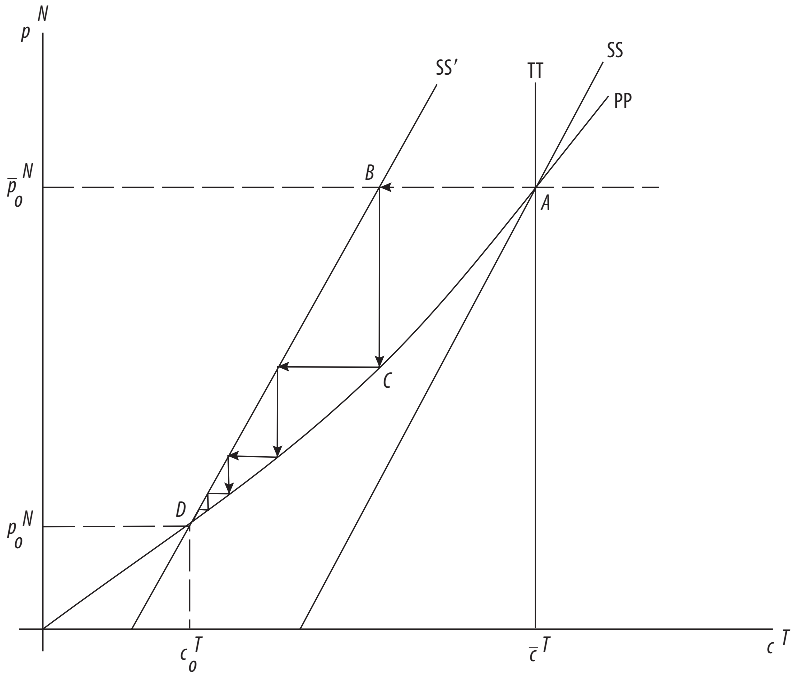


figure 2, SS corresponds to the case when $y_0^T = \hat{y}^T$, so that tradables output is just at the point where the credit constraint is marginally binding. In this case, SS intersects TT and PP at point A, so that the outcome with constrained debt is the same as the perfectly smooth case.

Consider a wealth-neutral shock to the tradables endowment at date 0 such that $y_0^T < \hat{y}^T$. The SS curve shifts to SS′, and the new equilibrium is determined at point D. If prices did not respond to the drop in consumption, or if the borrowing constraint were set as a fixed amount independent of income and prices, the new equilibrium would be at point B. At B, however, tradables consumption is lower than in the perfectly smooth case, so equilibrium requires the price of nontradables to fall. If the credit constraint were independent of the nontradables price (as, for example, in Calvo's setup), the new equilibrium would be at point C, with a lower nontradables price and lower tradables consumption.[31] This outcome reflects the balance sheet effect induced by liability

31. Calvo (1998).

dollarization, but Fisher's deflation has not yet been taken into account. The lower price at C on the PP line reduces the value of the nontradables endowment, which tightens the liquidity constraint and forces tradables consumption to fall so as to satisfy the constraint at a point on SS′. At that point, the nontradables price must fall again to regain a point along PP, but at that point, tradables consumption also falls again because the credit constraint tightens further. Fisher's debt-deflation process continues until it converges to point D, where the liquidity constraint is satisfied for a nontradables price and a level of tradables consumption that are consistent with the equilibrium condition for sectoral consumption allocations. In short, the response to the tradables endowment shock, which would be at point A for any shock that satisfies $y_0^T \geq \hat{y}^T$, is amplified to point D because of the combined effects of the balance sheet effect and Fisher's deflation.

The above results also apply to the case in which there is no shock to the tradables endowment, but the government increases τ_0 by enough to generate a drop in p_0^N that puts $\hat{y}^T$ above y_0^T. In this case, a policy change that may be intended to yield a small real depreciation of the currency can trigger the credit constraint, resulting in a large current account reversal and a collapse in tradables consumption, the price of nontradables, and the real exchange rate. The policy neutrality of the perfectly smooth case no longer holds.

One caveat of this analysis is that for a low enough y_0^T, the economy would not be able to borrow at the competitive equilibrium. This occurs when y_0^T is so low that the level of debt that satisfies the liquidity constraint exceeds Ω (or, in this case, the debt that would be contracted in the perfectly smooth equilibrium). Setting debt at this debt ceiling would imply a nontradables price at which the liquidity constraint is violated, while the debt level that satisfies equations 13 and 14, so that the liquidity constraint holds, would violate the debt ceiling. At corners like these, debt is set to zero and the economy is in financial autarky. The remainder of this paper concentrates on situations in which shocks result in values of $y_0^T \leq \hat{y}^T$, such that there are internal solutions with debt (that is, solutions for which Ω is not binding).

Further analysis of figure 2 raises questions about the existence and uniqueness of the equilibrium with Fisher's deflation, depending on assumptions about the position and slope of the SS line and the curvature of the PP curve. The model produces results that shed light on this issue, but they are highly dependent on the simplicity of the setup, which is aimed at deriving tractable analytical results to illustrate the effects of Fisher's deflation. The following results regarding the conditions that can produce or rule out multiple equilibria should be considered with caution, as they may not be robust to important extensions of the model (such as including uncertainty, capital accumulation, or a labor market).

Figure 2 suggests that a sufficiency condition to ensure a unique equilibrium with Fisher's deflation (for cases with $y_0^T \leq \hat{y}^T$ that yield internal solutions with debt) is that the PP curve be flatter than the SS line around point A. Since SS is an upward-sloping, linear function and PP is increasing and strictly convex, this assumption ensures that the two curves intersect only once in the interval between 0 and $\overline{c}^T$.[32]

Given equations 13 and 14, the assumption that PP is flatter than SS around point A implies that

$$(16) \qquad \kappa < \frac{1}{1+\mu} z \quad \text{with} \quad z = \frac{\left(\overline{c}^T / \overline{y}^T\right)}{\left[\left(\overline{p}_0^N \overline{y}^N\right) / \overline{y}^T\right]},$$

where $1/(1 + \mu)$ is the elasticity of substitution in the consumption of tradable and nontradable goods.

Condition 16 sets an upper bound for the liquidity coefficient, κ; this is different from the upper bound identified earlier, which determined a value of κ that is high enough to make the liquidity constraint irrelevant. Since in most countries the nontradables sector is at least as large as the tradables sector, and consumption of tradables is lower than tradables output, it follows that $z < 1$. Equation 16 thus states that the sufficiency condition for a unique equilibrium with Fisher's deflation requires the liquidity coefficient to be lower than the fraction, z, of the elasticity of substitution.

Existing empirical studies for developing countries show that the elasticity of substitution is less than unitary, ranging between 0.4 and 0.83.[33] In an early paper, I report sectoral data for Mexico indicating that, on average over the 1988–98 period, $(\overline{p}_0^N \overline{y}^N / \overline{y}^T) = 1.543$ and $(\overline{c}^T / \overline{y}^T) = 0.665$, so that in Mexico $z = 0.43$.[34] Given this value of z, supporting a debt-output ratio of about 36 percent requires using the upper bound of the estimates of the elasticity

32. Unless PP and SS are tangent at point A, the curves also intersect once in the region with $c_0^T > \overline{c}^T$, because equations 13 and 14 can be satisfied by setting c_0^T high enough to yield a p_0^N at which the credit constraint supports the high debt needed to finance this high consumption. This outcome is not an equilibrium, however, because the resulting debt level violates the debt ceiling (which is the debt of the perfectly smooth case implicit at point A).

33. See Ostry and Reinhart (1992); Mendoza (1995); Neumeyer and Gonzales (2003); Lorenzo, Aboal, and Osimani (2003).

34. Mendoza (2002).

of substitution—that is, $1/(1 + \mu) = 0.83$.[35] With this elasticity and $z = 0.43$, condition 16 implies that $\kappa < 0.357$. This result also meets the condition required for the credit constraint to bind at positive values of the tradables endowment,

$$\kappa < \kappa^h = \frac{1 - \left(b_0 / \bar{y}^T\right)}{\left[\left(\bar{p}_0^N \bar{y}^N\right) / \bar{y}^T\right]},$$

for any $b_0 \leq 0$. This rough review of empirical facts thus suggests that the sufficiency condition for which the model yields a unique equilibrium with Fisher's deflation is in line with the data.

Quantitative Implications: Balance Sheet Effect versus Fisher's Deflation

What are the relative magnitudes of the balance sheet effect and Fisher's deflation that move the economy from point A to point D in figure 2? The figure suggests that for a given value of the tradables endowment shock, the magnitude of the two effects depends on the curvature of SS and PP, which in turn depends on the relative magnitudes of the liquidity coefficient and the sectoral elasticity of substitution in consumption.

A lower liquidity coefficient increases the slope of the SS curve. This strengthens the balance sheet effect, but its effect on Fisher's deflation is not monotonic. Starting from a high κ at which the credit constraint was just marginally binding (so Fisher's deflation was irrelevant), lowering κ strengthens Fisher's deflation. As κ falls further, Fisher's deflation weakens because the feedback between the nontradables price and the ability to borrow weakens. (In the limit, for $\kappa = 0$, there is no Fisher's deflation, as is also the case when κ is too high for the credit constraint to ever bind.) A higher elasticity of substitution between tradables and nontradables makes the PP curve flatter, which strengthens both the balance sheet effect and Fisher's deflation.

The following numerical experiments illustrate the potential magnitudes of the balance sheet effect and Fisher's deflation, using a set of parameter values and calibration assumptions that match some empirical evidence from Mexico. These experiments use a constant relative risk aversion (CRRA) period utility function, $u(c) = (c^{1-\sigma})/(1 - \sigma)$, and a CES aggregator for sectoral consumption,

35. The 36 percent debt ratio is the lowest ratio of net foreign assets to output estimated for Mexico by Lane and Milesi-Ferretti (2001).

$$c = \left[a\left(c^T\right)^{-\mu} + \left(1 - a\right)\left(c^N\right)^{-\mu} \right]^{-1/\mu}.$$

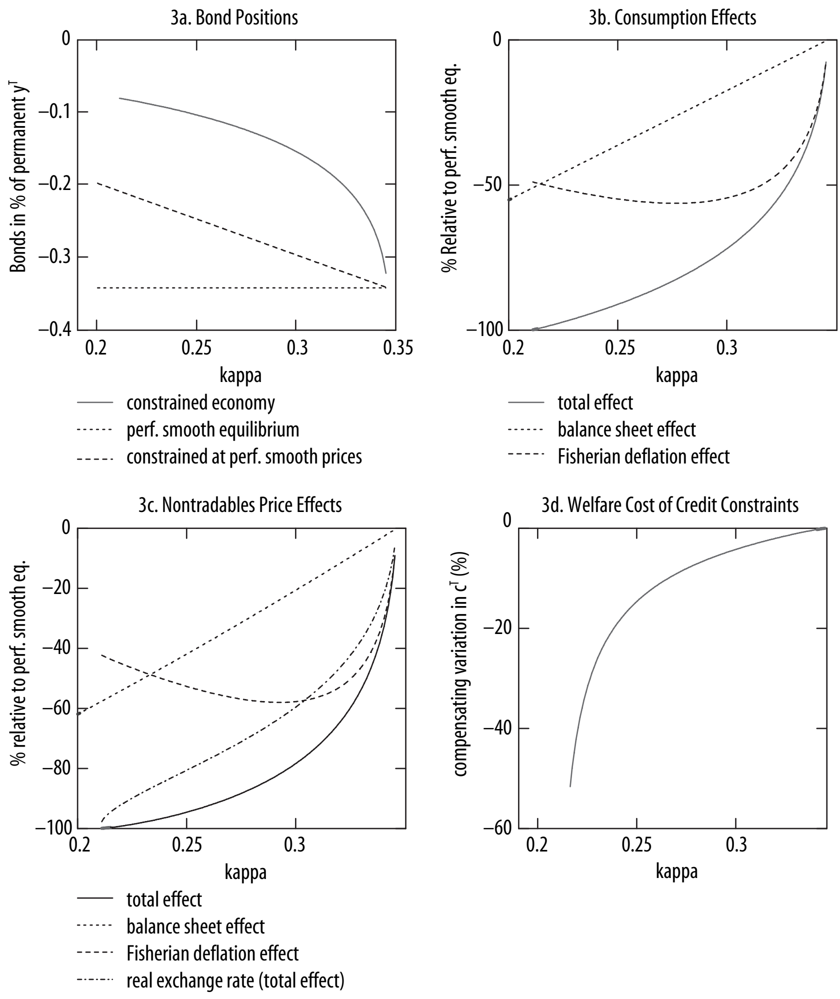
The subjective discount factor and the coefficient of relative risk aversion are set to standard values of $\beta = 0.960$ and $\sigma = 2.000$. I use an earlier estimate of the share parameter of the CES aggregator for Mexico, $a = 0.342$.[36] The elasticity of substitution between tradables and nontradables is set to the upper bound of the range of estimates cited earlier (0.830), which implies that $\mu = 0.204$.

The model is calibrated to match earlier estimates of Mexico's ratio of nontradables GDP to tradables GDP at current prices (1.543), as well as the sectoral shares of tradables (nontradables) consumption in tradables (nontradables) GDP, which are 66 percent and 71 percent, respectively.[37] Total permanent output is normalized to 1, so that the results of the quantitative experiments can be interpreted as shares of permanent GDP. I also allow for permanent absorption of tradables and nontradables including government purchases and private investment, to match the model with observed consumption-output ratios. The tax rate is set to zero, which implies a baseline scenario in which government expenditures are financed with lump-sump taxation. Initial external debt is set to one-third of permanent GDP, in the range of the time series of the ratio of net foreign assets to GDP produced for Mexico by Lane and Milesi-Ferretti.[38] With these calibrated parameter values, the perfectly smooth equilibrium yields consumption allocations of $\bar{c}^T = 0.26$ and $\bar{c}^N = 0.56$, with an equilibrium price of nontradables of $\bar{p}^N = 0.77$. The aggregate consumption-output ratio thus matches the ratio from Mexican data: $(\bar{c}^T + \bar{p}^N\bar{c}^N) / (\bar{y}^T + \bar{p}^N\bar{y}^N) = 0.69$.

Figure 3 illustrates the quantitative predictions of the model for a range of values of the liquidity coefficient $0.21 < \kappa < 35$, assuming a shock that lowers y_0^T to 3 percent below its permanent level. The lower bound of the liquidity coefficient is the lowest value of κ that can support positive tradables consumption with a binding liquidity constraint. The upper bound is the highest value of κ at which the constraint still binds; higher values would imply that the credit constraint does not bind for the 3 percent shock to tradables income, and the perfectly smooth equilibrium would be maintained.

36. Mendoza (2002).
37. Mendoza (2002).
38. Lane and Milesi-Ferretti (2001).

FIGURE 3. Date-0 Effects of Changes in the Liquidity Coefficient κ



Panel A of the figure shows the economy's bond position at date 0 in three situations: with a binding credit constraint, with perfect credit markets (that is, a perfectly smooth equilibrium), and with a credit constraint evaluated at the prices of the perfectly smooth equilibrium (that is, the value of the fraction κ of income valued at tradable goods prices in this same economy). The credit constraint binds whenever the third curve (credit constraint evaluated at perfectly smooth prices) is above the second (perfect credit markets). The vertical distance between the curve for the credit constraint evaluated at the prices of the perfectly smooth equilibrium and the binding constraint curve represents the effect of the endogenous collapse in the price of nontradables on the ability to contract debt. This effect grows very rapidly as κ falls, and it can imply a correction in the debt position (and in the current account) of over 10 percentage points of permanent GDP.

Panels B and C illustrate the effects of the credit constraints on tradables consumption, the relative price of nontradables, and the real exchange rate (with each measured as a percent deviation from their values in the perfectly smooth equilibrium). The plots decompose the total effect of the constraints on tradables consumption and the nontradables price into two components: namely, the balance sheet effect and Fisher's deflation. The total effect corresponds to a comparison of points A and D in figure 2. The balance sheet effect compares points A and C, and Fisher's deflation compares points C and D.

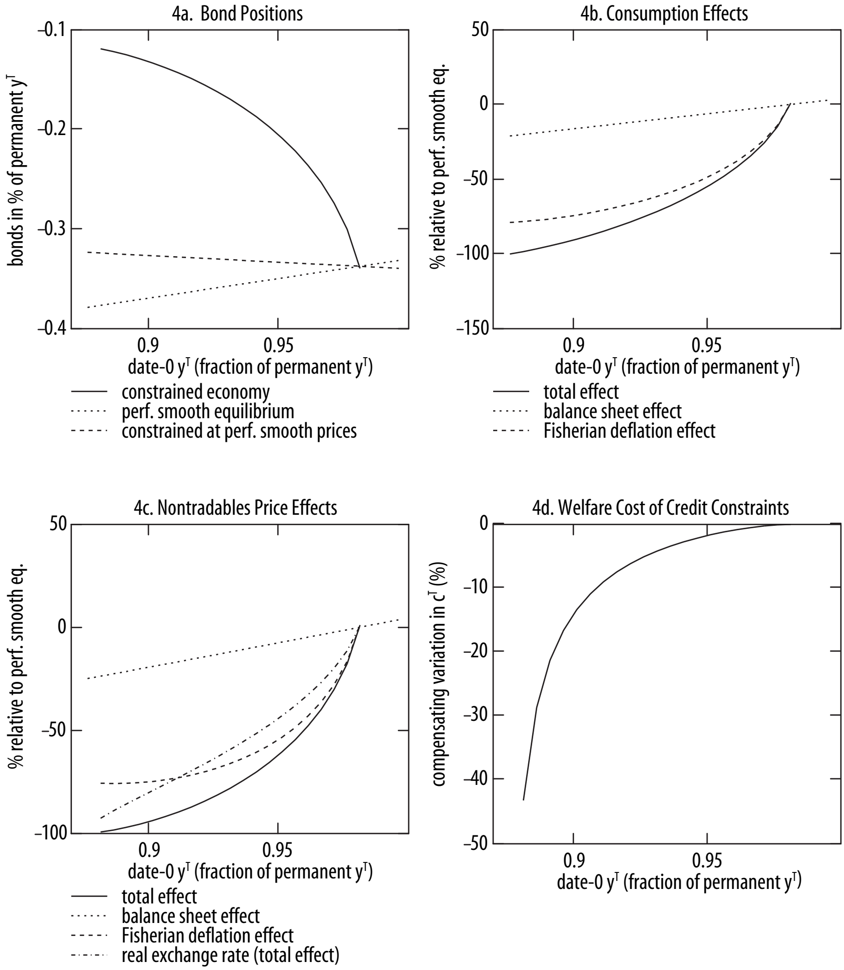
The negative effects of the liquidity constraint on tradables consumption and the relative price of nontradables are large and grow rapidly as κ falls. With κ set at 33 percent, tradables consumption and the nontradables price fall by nearly 50 percent, and the CPI-based measure of the real exchange rate (that is, the CES price index associated with the CES aggregator of sectoral consumption) falls nearly 37 percent. These declines are driven mainly by Fisher's deflation, as the contribution of the pure balance sheet effect is less than 7 percent for both tradables consumption and the nontradables price.

The effect of Fisher's deflation is strongest with κ around 30 percent, and it becomes weaker for lower values of κ. In the worst-case scenario, with κ at 20 percent, tradables consumption and the nontradables price approach zero. Even for these low values of the liquidity coefficient, however, the contribution to the collapse in consumption and prices is split fairly evenly between the balance sheet effect and Fisher's deflation. Hence, the contribution of Fisher's deflation process is at least as large as that of the balance sheet effect.

Panel D shows the welfare cost of the sudden stops shown in panels A through C. Welfare costs are computed as compensating variations in a time-invariant consumption level that equates lifetime utility in the credit-constrained economy with that of the economy with perfect credit markets (in which the perfectly smooth equilibrium prevails at all times). With κ at 33 percent, the welfare loss measures 1.1 percent, and the loss increases rapidly as κ falls.

Figure 4 illustrates the results for variations in the magnitude of the adverse shocks to the tradables endowment at date 0, while fixing κ at 34 percent. The shocks range between 0.0 and 12.4 percent of the permanent tradables

FIGURE 4. Date-0 Effects of Shocks to Tradables Endowment



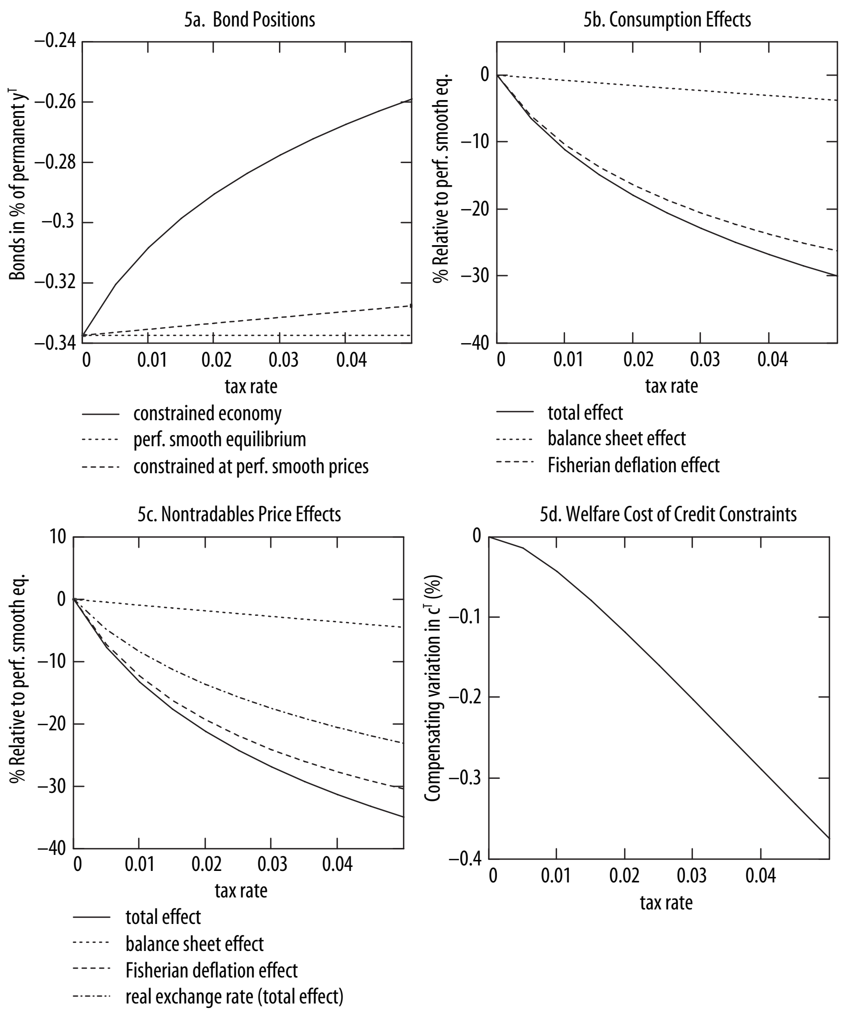
endowment (1.000 – 0.124 = 0.876 and 1.000 in the horizontal axes of the plots). In this experiment, the smallest shock for which the liquidity constraint begins to bind is 1.9 percent, so shocks between 0.0 and 1.9 percent do not trigger the constraint and yield the perfectly smooth equilibrium. The upper bound of the shocks (12.4 percent) is the largest shock that satisfies the maximum debt constraint (that is, the constraint stating that debt must not exceed the level corresponding to the perfectly smooth equilibrium).

The adjustment in the debt position is severe and increases rapidly with the size of the shock. A 5 percent shock to the tradables endowment implies a reduction in debt of about 15 percentage points of permanent income. Tradables consumption and the nontradables price fall about 60 percent below the levels of the perfectly smooth equilibrium, with most of the decline accounted for by Fisher's deflation. The CPI-based measure of the real exchange rate drops by about 47 percent. The welfare loss measures 1.7 percent in terms of a compensating variation in a lifetime-utility-equivalent level of consumption. All these effects—except the contribution of Fisher's deflation—grow rapidly as the size of the shock increases.

Finally, consider a policy experiment that switches from the tax rate consistent with a fixed exchange rate (that is, $\tau = 0$) to a floating exchange rate for which the currency's depreciation rate settles at levels consistent with a fixed, positive value of τ (alternatively, this experiment can be viewed as a case in which the government aims to induce a real depreciation by increasing τ). This experiment sets $y_0^T = \hat{y}^T$, which by construction implies that the credit constraint is marginally binding at a zero tax rate (that is, when $\tau = 0$, the economy is at point A in figure 2). Figure 5 shows the results of tax increases varying from 0 to 5 percent. Since the credit constraint is marginally binding at a zero tax rate and $y_0^T = \hat{y}^T$, and since with a nonbinding credit constraint the tax hike would induce at most a 3 percent real depreciation (if the tax were raised to the 5 percent maximum), the government could have good reason to expect the tax hike to induce a small real depreciation. As the panels in figure 5 show, however, the actual outcome would deviate sharply from this expectation because increasing the tax triggers the credit constraint. Increasing the tax rate by 5 percentage points induces a correction of 8 percentage points of permanent tradables income in the net foreign asset position of the economy. Consumption falls by 30 percent relative to the perfectly smooth equilibrium, the relative price of nontradables drops by 35 percent, and the real exchange rate depreciates by about 23 percent. As in the other two experiments, the amplification in the declines of consumption, the nontradables price, and the real exchange rate is largely due to Fisher's debt-deflation effect, with a negligible contribution from the balance sheet effect. This policy-induced real depreciation results in a welfare loss of nearly 0.4 percent in terms of a stationary tradables consumption path.

In summary, the results of these numerical experiments suggest that in the presence of liability dollarization and credit-market frictions, Fisher's deflation mechanism can be an important source of amplification and asymmetry in emerging economies' response to negative shocks. Fisher's deflation causes

FIGURE 5. Date-0 Effects of a Policy-Induced Real Depreciation



large declines in consumption and the nontradables price, as well as large real depreciations and large reversals in the current account. In this environment, policy-induced real depreciations can trigger the credit constraints and Fisher's deflation mechanism, resulting in a collapse in the nontradables price and large real depreciations of the currency. Fisher's deflation mechanism may thus help account for the empirical observation that the relative nontradables price accounts for a significant fraction of the variability of the real exchange rate in economies with managed exchange rate regimes.

Conclusions

This paper has reported evidence based on Mexican and U.S. monthly data for the 1969–2000 period showing that—when Mexico was under a managed exchange rate regime—fluctuations in Mexico's relative price of nontradable goods account for 50 to 70 percent of the variability in the Mexico-U.S. real exchange rate. The main lesson drawn from this evidence, and from cross-country studies by Naknoi and Parsley, is that the behavior of the determinants of the real exchange rate differs sharply between countries with features similar to Mexico's and the industrial countries to which variance analysis of real exchange rates is normally applied.[39] In particular, the overwhelming role of movements in tradable goods prices and nominal exchange rates found in industrial countries and in developing countries with floating exchange rates falls sharply in developing countries with managed exchange rates.

This finding suggests that liability dollarization is rightly emphasized in the sudden stops literature. This paper proposed a basic model to illustrate how liability dollarization introduces amplification and asymmetry in the responses of the economy to adverse shocks via a financial accelerator that combines a balance sheet effect with Fisher's debt-deflation mechanism. The balance sheet effect and Fisher's deflation result in a collapse in the real exchange rate, driven by a collapse in the relative price of nontradables. A set of basic numerical experiments suggests that the quantitative implications of these frictions, particularly Fisher's deflation, can be significant. In the case of a policy-induced real depreciation (or a shift from a fixed exchange rate regime to a constant, positive depreciation rate), this paper's financial accelerator produces large collapses in the relative nontradables price, the real exchange rate, and consumption, together with a large current account reversal (starting from a situation in which credit constraints were marginally binding).

The results indicate that roughly half of the variability of the real exchange rate can be attributed to movements in nontradables prices. This is in line with the quantitative findings of the recent literature on the business cycle

39. Naknoi (2005) and Parsley (2003) demonstrate that this result is robust across developing countries.

implications of exchange rate management.[40] Further empirical research should focus on comparing the experiences of industrial and developing countries so as to shed more light on whether variance analysis of other real exchange rates pairing emerging markets and industrial countries displays a similar sensitivity to the exchange rate regime as the real peso-dollar exchange rate.[41] Another important issue is whether the role of the nontradables price in accounting for real exchange rate variability depends on the degree of liability dollarization in the economy.

The paper intentionally avoided taking a position on the best modeling strategy to account for the nontrivial fraction of real exchange rate variability explained by movements in tradable goods prices and the nominal exchange rate. In particular, the evidence reported here for periods without exchange rate management, in which a large fraction of real exchange rate variability is due to changes in relative tradables prices and the nominal exchange rate, does not suggest per se that one should view fluctuations in the variable x as deviations from the law of one price or evidence of price or wage stickiness. It simply shows how much x (that is, the ratio of exchange-rate-adjusted CPI prices of durable goods across Mexico and the United States) contributes to explaining the variance of the ratio of exchange-rate-adjusted aggregate CPIs. This is far from the ideal scenario needed to interpret changes in x as deviations from the law of one price. The law of one price applies to single, homogeneous goods sold in a freely accessible market and in the absence of frictions like transportation costs and tax or tariff distortions. Clearly, aggregate data for the Mexican and U.S. CPIs violate these conditions. The indexes include different goods, the goods carry different weights, and the weights change at different intervals. Access to a common market varied widely over the sample period and across goods, and similar caveats apply to transportation costs and tariffs.[42]

The treatment of the data here abstracts from medium- to low-frequency considerations, including those related to mean-reverting properties of real exchange rates and to the long-run determination of real exchange rates.

40. See Mendoza and Uribe (2000).

41. Naknoi (2005) and Parsley (2003) are good examples of this approach.

42. A number of detailed studies on purchasing power parity (PPP) and the law of one price take the above issues into account and still find evidence of large price differentials for highly disaggregated consumer goods. Some researchers are concerned with the impossibility of defining a pure concept of tradable goods as required by the law of one price, and they thus study the "degree of tradability of goods" or distribution costs. See Betts and Kehoe (2000); Burstein, Neves, and Rebelo (2003).

Research in this direction is inconclusive, as the survey by Froot and Rogoff shows.[43] In this paper, variance ratios based on seventy-two-month differences of the data, which correspond to the six-year periodicity of recent Mexican business cycles, show that the contribution of x to the variance of the real exchange rate is about 65 percent, both for the full sample and for the period of the managed exchange rate that ended in 1994.

This paper provides an argument in favor of policies that seek to stabilize the real value of the currency. Traditional exchange rate management is not useful because currency collapses trigger large movements in relative prices, together with sudden stops in consumption and the current account. Instead, the model favors policies that can successfully prevent large fluctuations in the real exchange rate. The setup of the model highlights, in particular, the use of sectoral tax policy to contain the deflationary pressure on the relative price of nontradables as this pressure builds up. Policies that point in the same direction include the removal of the liability dollarization problem (for example, the full adoption of a hard currency as the domestic currency) or the prevention of large swings in the real value of the currency under a de jure floating exchange rate (as may be occurring in practice in many emerging countries that claim to stick to inflation targeting rules).

An alternative to policies that prevent large fluctuations in the relative price of nontradables is to make emerging economies' debt instruments less susceptible to adverse balance sheet effects and Fisher's deflation. This is in line with recent proposals to issue bonds only in domestic currencies or indexed to the evolution of output or key commodity prices (as was done by Argentina in its recent debt conversion, using bonds partially indexed to output). But whether emerging economies can successfully establish liquid markets for these instruments unilaterally, or whether there is enough interest in them in world financial markets, remains an open question. Clearly, if creating markets for the state-contingent claims that can neutralize financial accelerator mechanisms driving sudden stops is feasible, this is the most preferable policy. If not, domestic policies aimed at stabilizing the relative price of nontradables are an appealing alternative.

43. Froot and Rogoff (1995). For example, Asea and Mendoza (1994) find that while the data support predictions of long-run neoclassical models in which cross-country differences in the relative nontradables price reflect differences in productivity across sectors that produce tradables and nontradables, measures of the long-run relative nontradables price do poorly in explaining cross-country differences in CPI-based measures of the real exchange rate.