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NOTES ON PRICE STICKINESS:
With Special Reference to Liability Dollarization and Credibility

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I. Introduction

This paper is motivated by trying to understand the implication of price stickiness in Emerging Market economies, EMs. The issue is important because EMs are subject to significantly higher volatility of fundamentals than advanced countries (see Hausmann and Rojas-Suarez (1996)). Thus, full-equilibrium relative prices are also likely to exhibit large volatility in EMs, making price stickiness an even more critical issue in EMs than in advanced countries.

In addition, price stickiness has been at the heart of the debate on fixed vs. flexible exchange rates (see De Grauwe (1994)). This debate has acquired further relevance and urgency given the recent financial turmoil in EMs. Actually, recent crises have revealed a major flaw in the traditional approaches to this debate: Most discussions completely ignore issues like balance-sheet vulnerabilities and partial dollarization (see Calvo (2000)). Thus, for example, a large number of EMs utilize foreign exchange (typically the US dollar) for transactions, precautionary or store of value purposes, and denominate their debts in foreign exchange (see IMF (1999), Calvo (2000)). The latter, which I will call *liability dollarization*, LD, contributes to balance-sheet vulnerability as a result of exchange rate fluctuations if dollar debts are not matched by dollar revenues. This is typically the case in heavily dollarized EMs that have not taken the ultimate step of abandoning their domestic currencies (i.e., *full dollarization*). This type of vulnerability would not be a serious, however, if firms' revenues were highly correlated with the exchange rate. But this does not seem to be the case in practice. One important reason is price stickiness. Thus, the question arises, what keeps price setters from changing their prices when a devaluation threatens to bring them to bankruptcy? Why are prices set in domestic currency and

not foreign exchange, etc.?

Price stickiness is an important issue even if prices are set in foreign exchange. Evidence from recent crises suggests that external factors play a major role. Seemingly, countries can be cut out of the international capital market as a result of crisis in other parts of the globe (i.e., *contagion*). The associated changes in capital inflows can be large and have major contractionary effects on output (see Calvo and Reinhart (1999)). Thus, even in a fully dollarized economy, large swings in capital inflows may necessitate sizable changes in the real exchange rate (i.e., the relative price of nontradables in terms of tradables).¹ Does price stickiness help or hurt? If traditional arguments are wielded, then price stickiness hurts. However, if balance-sheet considerations are brought to bear, the answer is ambiguous. Sectors who are bound to see their relative price fall, may benefit from gradual approach to equilibrium. *A gradual decline in prices could provide these sectors with temporary monopoly profits and help them avoid bankruptcy.*

The paper utilizes two popular workhorses of modern macroeconomics: (1) Dixit-Stiglitz (1979) product variety model, and (2) Calvo (1983) staggered prices model. There are two types of goods: tradables and nontradables. Nontradables are modeled *à la* Dixit-Stiglitz, while tradables are subject to perfect competition. Thus, the price-setting action occurs entirely in the nontradables' sector.

¹ It is becoming standard in the literature to call *Sudden Stops* large capital inflow reversals (i.e., large negative changes – typically containing a large unanticipated component – in capital inflows which, however, do not necessarily result in capital *outflows*). I have argued elsewhere that the real currency depreciation called for by Sudden Stops may bring about the type of balance-sheet problem emphasized by Fisher (1933) in his classical Debt Deflation paper (Calvo (1998)).

Section II discusses price-change incentives in a static, one-period, context. First, it examines optimal price setting by the individual firm in the nontradables' sector. Results here are not particularly novel, but the paper highlights a result which relevance appears to have been missed in the literature, namely, that the higher is the elasticity of substitution between any two nontradable goods, the closer to the average price of nontradables will be the individual firm's optimal price. Since the case of perfect substitutability corresponds to *perfect competition* in this model, the result implies that *in highly competitive systems, individual firms will have incentives to "follow the pack," and set their price very close to the average.* Second, Section II studies the factors that increase or decrease the incentive to modify the price of a given nontradable good, if the initial price happens to be non optimal. In particular, the paper focuses on the case in which, initially, the firm "follows the pack" and sets its price equal to the average for nontradables. An interesting result is that *the more mutually substitutable are nontradables, the higher the incentives to move out of the pack and set prices optimally.* This result shows that even though in highly competitive economies firms operate very close to the average, departing from the average could still be attractive—implying that close to full price flexibility could prevail. Simulations, however, suggest that the gains from optimal pricing may be quite small. In addition, if there is an upper bound to the frequency of price revisions, the first type of effect will eventually dominate. Third, Section II discusses the logical connections between price stickiness, dollar-pricing and LD. It argues that there is no necessary close link between LD and either dollar pricing or the degree of price stickiness. High LD could be consistent with domestic-currency pricing and slow price adjustment. Four, Section II shows that a gradual approach to full equilibrium from a low-output equilibrium (a recession, say) will increase profits

and, thus, possibly stave away bankruptcy.

In Section III the Dixit-Stiglitz model is imbedded in a Calvo-type staggered prices model (Calvo (1983), Woodford (1996)). A central result is that if the first type of effect highlighted above dominates, *highly competitive economies will display very sluggish price adjustment towards full equilibrium*. In addition, Section III analyzes the effect on the real exchange rate of anticipated future inflation. The key finding is that real currency appreciation is enhanced by slow adjustment. Thus, together with the above result, the paper suggests that *highly competitive systems may display large swings in the real exchange rate as a result of incompletely credible policy or policymakers*.

II. Incentives for Price Stickiness

The main objective of this section is to identify incentives for price stickiness, and to study the connection between price stickiness and financial vulnerability, especially in the case in which firms take foreign-currency denominated debt.

I will conduct the discussion in the context of a Dixit-Stiglitz (1977) model in which there are tradable and nontradable goods. Tradables are perfectly homogeneous, while nontradables form a continuum on the unit interval, and exhibit a monopolistic-competition market structure. Each nontradable firm produces an exclusive good and is tiny in relation to the market. Nontradable firm j is identified with individual j . Thus, individual j produces nontradable good j . Nontradables are produced with tradables and a fixed factor (e.g., land), and the production function is Cobb-Douglas. Thus, denoting by H_j and y_j the output of nontradable j and the input of tradables in the production of j , we have

$$y_j = \xi H_j^\gamma, \quad \gamma > 1, \xi > 0. \quad (1)$$

The production function is the same for all j .

The utility function of individual j satisfies:

$$u(x_j) + c_j, \quad (2)$$

where

$$x_j = \left[\int_0^1 (h_{jk})^{\frac{\alpha-1}{\alpha}} dk \right]^{\frac{\alpha}{\alpha-1}}, \quad (3)$$

and h_{jk} and c_j are the individual j 's consumption of nontradable k , and consumption of tradables, respectively; $\alpha > 1$.² Notice that utility function is the same for all individuals j .

The budget constraint of individual j is given by

$$\int_0^1 v_k h_{jk} dk + c_j + \xi H_j^\gamma = H_j v_j + z, \quad (4)$$

where v_k and z are, respectively, the relative price of nontradable k with respect to tradables, and per capita endowment of tradables (assumed constant across individuals for simplicity).

Individual j is a price taker for all non- j outputs. Therefore, the first-order conditions with respect to h_{jk} and c_j yield:

$$h_{jk} = x_j \left(\frac{p}{v_k} \right)^\alpha, \quad (5)$$

² Parameter α is restricted to be larger than unity to ensure existence of an interior optimum in the price-setting problem discussed below.

where p is an average price of nontradables defined as follows:

$$p = \left(\int_0^1 v_k^{1-\alpha} dk \right)^{\frac{1}{1-\alpha}}. \quad (6)$$

Moreover, by equations (5) and (6), a necessary condition for utility maximization is that

$$\int_0^1 v_k h_{jk} dk = px_j, \quad (7)$$

implying that an optimum (noting that the associated Lagrange multiplier is equal to unity), we have

$$u'(x_j) = p \quad (8)$$

Let us define

$$X = \int_0^1 x_k dk, \quad (9)$$

and

$$H_k^d = \int_0^1 h_{jk} dj = \text{market demand for } k, \quad (10)$$

Thus, by (5), (8), and (9),

$$H_k^d = X \left(\frac{p}{v_k} \right)^\alpha. \quad (11)$$

In contrast with consumption, in choosing the output of good j individual j will take into

account that this decision affects its market price, i.e., v_j . More specifically, the optimal supply of nontradable j corresponds to the value of H_j^d that maximizes utility (2) subject to budget constraint (4) and market demand equation (11). Thus, formally the problem could be stated as choosing v_j such that it maximizes:

$$\omega_j \equiv v_j H_j^d - \xi H_j^\gamma, \quad (12)$$

subject to $H_j^d = H_j$, and equation (11). Therefore, optimal v satisfies:

$$v_j = p^{\frac{\alpha(\gamma-1)}{1+\alpha(\gamma-1)}} \left(\frac{\xi X^{\gamma-1} \alpha \gamma}{\alpha-1} \right)^{\frac{1}{1+\alpha(\gamma-1)}}. \quad (13)$$

I will conduct the discussion for the case in which $u(x) = \ln x$. Thus, by equations (8) and (9), we have

$$pX = 1, \quad (14)$$

and, full equilibrium output, X^e ,

$$X^e = \left(\frac{\alpha-1}{\alpha} \frac{1}{\xi \gamma} \right)^{\frac{1}{\gamma}}, \quad (15)$$

which, as is well known, is smaller than perfect-competition output, i.e., $(\xi \gamma)^{-1/\gamma}$. Notice that perfect-competition output is the limit of x as nontradables become perfect substitutes (i.e., as $\alpha \rightarrow \infty$).

Equation (13) gives the optimal price for firm j taking all other prices and market

conditions as given. Therefore, (13) is an equation that holds under a variety of circumstances, e.g., the case in which competitors' prices are predetermined, and output in the nontradable sector is demand-determined. Taking logs in equation (13), we get

$$\ln v_j = \frac{\alpha(\gamma-1)}{1+\alpha(\gamma-1)} \ln p + \frac{1}{1+\alpha(\gamma-1)} \ln\left(\frac{\xi\alpha\gamma X^{\gamma-1}}{\alpha-1}\right). \quad (16)$$

Interestingly, as the system becomes more competitive, firm j increases the weight on the average price set by its competitors, p . Actually, as $\alpha \rightarrow \infty$, v_j converges to p (in logs), and is totally unaffected by aggregate demand considerations (captured by X). This straightforward result, which relevance has apparently escaped the macro literature, has important implications for the rate of convergence to full employment in a staggered-prices setup (this is discussed in the next section). Clearly, if price setters were to pay no heed to aggregate demand considerations, they will simply replicate the price set by their competitors and there would be no tendency for the system to return to full employment (as in simple IS-LM models with no price-adjustment mechanism). The economics behind equation (16) are also straightforward. As the system becomes more competitive (i.e., as α goes up), the demand for a given firm becomes more sensitive to changes in its price relative to that of its competitors, but it does not necessarily imply any change of sensitivity with respect to aggregate demand (this is clearly borne out by equation (11)). An interesting implication of this discussion is that ***given the average contract length in a staggered-prices model, convergence to full employment equilibrium may actually become more sluggish as the economy converges to perfect competition*** (I will discuss this

result in the next section). However, it is to be expected that the incentives for price revision³ increase with the degree of competition (i.e., parameter α), a force that would tend to speed up convergence.

1. Incentive for Price Revisions. In view (12), (13) and (14), profits associated with the production of good j , ω_j , are given by

$$\omega_j = X^{1-\alpha} v_j^{1-\alpha} - \xi X^{\gamma(1-\alpha)} v_j^{-\alpha\gamma}. \quad (17)$$

Therefore, maximum profits given X , satisfies:

$$\left(\frac{X^e}{X} \right)^{\frac{\gamma(\alpha-1)}{1+\alpha(\gamma-1)}} \left[1 - \xi (X^e)^\gamma \right] = \left(\frac{X^e}{X} \right)^{\frac{\gamma(\alpha-1)}{1+\alpha(\gamma-1)}} \left(1 - \frac{\alpha-1}{\alpha\gamma} \right). \quad (18)$$

On the other hand, if firm j were to set its price equal to the price average in the nontradables sector (hence $v_j = p$) then, by equations (14) and (17), profits would be

$$1 - \xi X^\gamma. \quad (19)$$

I will compute the cost of “following the pack” as the loss of setting $v_j = p$ relative to maximum profit, i.e., expression (19) relative to expression (18). Numerical analysis suggests that the loss is an increasing function of the degree of competition (i.e., parameter α), as conjectured above.

Therefore, to get a sense of what happens when incentives for price revision are the highest, I

³ In a recent paper, Duca and VanHoose (2000) develop and estimate a model where the NAIRU is a negative function of the degree of goods competition. The underlying micro-model is not the same, but a similar effect is at work. In the present paper, however, I will emphasize the implication of goods competition on price sluggishness, rather than on the NAIRU which, by assumption, will be assumed constant.

will discuss Table 1 where the loss is computed for the case in which $\alpha \rightarrow \infty$.⁴ Table 1 assumes that $\gamma = 2$, implying that the cost of raw materials represents 50 percent of gross output in the nontradables sector. This appears to be a good first approximation (see Burstein, Neves and Rebelo (2000)). The first column in Table 1 registers nontradables' output relative to its full-equilibrium level (in percentage points), while the second column corresponds to the loss of profit from setting firm j 's price equal to the average p , relative to its maximum (i.e., expression (17)).⁵ Thus, for example, the third row of Table 1 shows that if nontradables' output is 5 percent less than at full equilibrium, then the loss from "following the pack" is 0.9 percent of maximum profit. Before assessing the quantitative significance of these numbers, notice that the losses from mispricing are larger in an "overheated" than in a recessionary economy. Thus, for instance, the profit loss if output is 10 percent larger than its full equilibrium level exceeds the loss when, contrariwise, output is 10 percent lower. Thus, *price revision incentives are higher in expansions than in recessions*, helping to rationalize the case of "downward price rigidity" which has played such an important role in the macroeconomics literature.

How big should mispricing losses be to make price revision attractive for an individual firm? A full answer to the question requires developing the microfoundations of price-change frictions and costs, an issue that falls outside the scope of this paper. However, the model still allows us to assess welfare costs. Suppose, for instance, that income from tradables represent roughly 50 percent of total income. This implies that, as a share of income measured in tradables, the losses registered in Table 1 should be halved. Moreover, these losses are

⁴ One can show that this loss function is invariant with respect to ξ .

⁵ The third column is discussed below.

temporary. In a staggered-prices context, for example, the individual firm would be able to set a new price when contracts expire, without incurring price-change costs. The shorter the duration of contracts, the smaller will be the cost of “following the pack” in terms of present discounted values. For example, if contracts’ duration is one month, the cost of mispricing in terms of one-year income would be $1/24$ multiplied by the second column in Table 1 ($1/12$ because it is one month in a full year *times* $1/2$ in view of the assumption that net income from nontradables corresponds to $1/2$ total income). Results are listed in the third column of Table 1. Under these assumptions, the loss from mispricing shrinks considerably, especially if the individual is faced with a disequilibrium situation that has a low probability of recurring, e.g., a deep recession. Finally, note that the loss from “following the pack” is an increasing function of the disequilibrium in aggregate demand X . This suggests, incidentally, that the *pass-through coefficient* which measures the elasticity of domestic prices with respect to the exchange rate could be highly nonlinear. The coefficient is likely to increase with the size of real exchange rate disequilibrium.⁶

2. Liability Dollarization and Pass-Through. The dollarization debate has highlighted the possible critical importance of *Liability Dollarization*, LD (i.e., foreign-exchange denominated debts). In an economy that exhibits a high incidence of LD, a devaluation could drive debtors to insolvency or serious liquidity straits (see Calvo (2000)).

Consider a situation in which the real exchange rate is too low (i.e., p is higher than full equilibrium p in our model). A devaluation could help the economy reach its full-equilibrium

⁶ This issue cannot be fully discussed in the present version of the model, because there is no explicit account of money or exchange rates. However, these intuitions will hold true in the monetary model of the next section.

solution in one shot. In contrast, if prices are sticky convergence to full equilibrium will be gradual. Which one of these transitions is better from a financial point of view? Consider the model developed in the first subsection. For the sake of concreteness, I will focus on the case in which initially all individuals have set $v = p$. Thus, profit is given by expression (19). Clearly, the smaller is aggregate demand X , the larger will be profits. This result is very intuitive. In our model, firms have some monopoly power but are far from being perfect monopolists. Thus, as profit-makers, they are producing *too much*. Under the present circumstances (p higher than full-equilibrium p), price stickiness helps to coordinate a solution where firms can get closer to the full-monopoly equilibrium and, therefore, cushion the financial impact of a lower equilibrium relative price.⁷ This gives some support to the view that flexible exchange rates could exacerbate financial problems in the home-goods sector.⁸

However, if LD is a major feature in the nontradables' sector, the question arises, Why are home-goods prices set in domestic currency and not in *dollars*? I will not attempt to give a thorough answer to this key question. I will argue, instead, that the presence of LD is, per se, not a determining factor in the choice of currency for quoting prices. Note, for instance, that if competitors set their prices in domestic currency, indexing to the dollar would make the firm in

⁷ For the log utility case, home-good sector profits monotonically increase as X goes to zero. Hence, there is no well-defined monopoly equilibrium, but that is not an issue that should concern us here.

⁸ If the disequilibrium goes in the opposite direction, i.e., if p is too low, a currency appreciation (not a devaluation) could bring the system to full equilibrium further increasing profits. Hence, without causing—and, in fact, possibly relieving—financial distress. However, this advantage from currency appreciation would not be significant if prices of nontradables are relatively upward-flexible. Previous numerical simulations suggested that upward could be more likely than downward price flexibility.

question grossly uncompetitive after a large devaluation (this holds especially as $\alpha \rightarrow \infty$).

A simple way to take explicit account of financial considerations in the above model is to assume that if profits fall below a certain critical level there is a lump-sum loss of tradables' endowment. This assumption does not change any first-order condition, and captures the social cost of bankruptcy. Moreover, LD could simply be captured by assuming that it materializes in a "low" level of tradables' endowment, enhancing the possibility of bankruptcy as a result of currency devaluation. Clearly, under the present circumstances LD does not create further incentives to set prices in foreign exchange. Thus, it is conceivable for an economy to exhibit a separation between financial and price-setting decisions, resulting in persistent currency mismatch unless the government coordinates a dollar-price equilibrium. A possible way to do this would be *full dollarization* (see Calvo (2000)).

The standard case for flexible exchange rates, in contrast, emphasizes the output loss associated with disequilibrium real exchange rates. This effect is also captured in our model. Consider the planner's problem. Clearly, it is optimal to produce the same amount of each type of nontradable. Therefore, by (1) and (4), the planner's budget constraint satisfies:

$$c = z - \xi x^\gamma. \quad (20)$$

Hence, recalling utility function (2), the planner's problem consists of maximizing the following expression with respect to x :

$$u(x) + z - \xi x^\gamma. \quad (21)$$

This is a strictly concave function with respect to x . Thus, any movement towards the planner's

optimum is utility-enhancing. Consider the case discussed above in which $u(x) = \ln x$.

Maximization of (21) with respect to x is obtained setting $x = X^p$, where

$$X^p = \left(\frac{1}{\xi\gamma} \right)^{\frac{1}{\gamma}}. \quad (22)$$

Thus, recalling expression (15), the planner's optimal output of nontradables, X^p , exceeds the full-equilibrium market solution. This is a well-known fact that is rendered more intuitive if one notices that the value of x given in (22) corresponds to the perfect-competition equilibrium in our model.

Let us come back to the earlier discussion in which $X < X^e$. Clearly, a devaluation that sets $X = X^e$ would be utility enhancing. In a more thorough analysis, this benefit from flexible exchange rates should be weighed against the financial difficulties that they may cause as a result of liability dollarization. For the sake of completeness, also note that the case $X > X^e$ is not symmetric. A currency appreciation that drives the economy to full equilibrium may not be utility-enhancing because $X^e < X^p$.

III. Staggered Prices: Dynamic Considerations

This section will embed the above model into a monetary framework with staggered prices. The objective is to prove more formally some of the intuitions derived from the previous discussion. In addition, the model will help to assess the real exchange disequilibrium that anticipatory price setting can generate when policy announcements are not fully credible.

First, let me start by expressing key equation (16) in a form that can more easily be related to the model in Calvo (1983):

$$V = P + \theta[A + (\gamma - 1)\ln X - P], \quad (23)$$

where $P = \ln p$, $V = \ln v$, $A = \ln [\xi\alpha\gamma/(\alpha - 1)]$, and

$$\theta = \frac{1}{1 + \alpha(\gamma - 1)}. \quad (24)$$

Therefore, by (14),

$$V = P + \theta(A - \gamma P). \quad (25)$$

In a staggered-prices context, however, V is set when a stochastic signal is received, and is fixed *in nominal terms* until a new signal is received (see Calvo (1983)). Moreover, V is assumed to be a weighted average of expressions like (24).⁹ Assuming that the price-change signal follows a geometric distribution with parameter δ , Calvo (1983) shows that

$$\dot{\pi}_t = -\delta^2\theta(A - \gamma P_t), \quad (26)$$

where π is the rate of inflation of nontradables. Moreover, by definition,

$$\dot{P}_t = \pi_t - \varepsilon_t, \quad (27)$$

where ε_t stands for the rate of currency devaluation.

⁹ The microfoundations of this assumption is presented in Woodford (1996). The very same formulas utilized in Calvo (1983) hold true as the discount rate goes to zero if (1) we assume a quadratic loss function that depends on the difference between V and its optimal level if V was fully flexible (e.g., formula (24)), (2) the objective function to be minimized is an expected present discounted sum of instant losses, and (3) the price-change signal follows a geometric distribution, is the same for all firms and is stochastically independent across firms.

First I will focus on the case in which ε is constant over time (this corresponds to the case in which the nominal exchange rate is credibly set to depreciate at constant rate ε).¹⁰ System (26)-(27) is linear and satisfies the saddle-path condition. By definition, rational expectations solutions lie on the stable branch, which can be shown to satisfy the following condition:

$$\pi = \delta \sqrt{\theta \gamma} \left(\frac{A}{\gamma} - P \right) + \varepsilon. \quad (28)$$

Hence, by (27) and (28),

$$\dot{P}_t = \delta \sqrt{\theta \gamma} \left(\frac{A}{\gamma} - P_t \right). \quad (29)$$

Recalling (24), this shows that the speed of adjustment to full equilibrium depends on three key parameters: δ (the inverse of the average contract length), α (the elasticity of substitution between any two different nontradable goods), and γ (the production function parameter). In particular, if the economy converges to perfect competition $\alpha \rightarrow \infty$, we have, by (24), $\theta \rightarrow 0$, formally showing the statement in the previous section that, given contract length, *convergence to full equilibrium becomes more sluggish as the economy moves closer to perfect competition*. On the other hand, *the shorter is contract length* (i.e., the larger is δ), *the faster is convergence to full equilibrium*. The discussion in the previous section suggested that the higher is α , the larger are incentives for price revision (i.e., the smaller is likely to be δ). Thus, moving towards more competition has ambiguous implications. However, to the extent that the information technology requires that prices be posted for a minimum length of time, the effect of higher α should

¹⁰ For greater detail on the cases highlighted this and the following example, see Calvo and Vegh (1999).

eventually dominate.

The discussion is particularly relevant for understanding the role of *wage and price flexibility*. Enhancing wage/price flexibility figures high in the list of policy advice given by multilateral institutions to EMs, especially those that adopt fixed exchange rates. Oftentimes it is asserted that removal of legal constraints to labor contracts coupled with an unleashing of competitive forces would bring the system close to the flexible wage/price textbook model. The above results cast some doubt about the logical basis for this implication and even the desirability of wage/price flexibility if one were to take into account balance-sheet considerations (e.g., liability dollarization).

1. Temporariness. Forward-looking price setting behavior can give rise to interesting dynamics, particularly when policy announcements are not fully credible (for a recent survey of this literature, see Calvo and Vegh (1999)). A simple case, which has received considerable attention in the literature, is one in which the rate of devaluation, ε , is announced by the policymaker at a low (say, 0) rate but the public expects that the policy will be abandoned after T periods when ε will be set at a permanently higher level. Formally, in the minds of the public, ε satisfies the following specification:

$$\begin{aligned}\varepsilon_t &= 0, 0 \leq t < T, \\ \varepsilon_t &= \bar{\varepsilon}, T \leq t, \bar{\varepsilon} > 0.\end{aligned}\tag{30}$$

It is well known that, starting from full equilibrium, the above configuration brings about real currency appreciation (i.e., P larger than full equilibrium P) before the policy-switch point T (see Calvo and Vegh (1999)). Under these circumstances, an unanticipated and credible once-

and-for-all devaluation could place the economy squarely at its full-equilibrium solution. The pass-through from devaluation to inflation will be zero or even negative. Thus, in the absence of balance-sheet problems, such devaluation will likely be placed in the Annals of Successful Devaluations in EMs: full equilibrium was achieved with no negative effect on output or employment! This phenomenon faces the econometrician with a serious challenge. A superficial reading of the situation, for example, may wrongly lead him/her to conclude that the pass-through coefficient is nil.¹¹ A relevant question in this respect is, How much currency appreciation could be explained by anticipatory behavior? This question has a simple answer in the context of the present model.

Without loss of generality, let us assume that parameter $A = 0$. Thus, full-equilibrium $P = 0$. The matrix associated with system (28)-(29) satisfies:

$$\begin{pmatrix} 0 & \delta^2\theta\gamma \\ 1 & 0 \end{pmatrix}. \quad (31)$$

Let us denote the eigenvalues by λ_i , $i = 1, 2$. Clearly,

$$\lambda_{1,2} = \pm\delta\sqrt{\theta\gamma}, \quad (32)$$

¹¹ The stylized facts described here are somewhat in line with recent developments in Brazil. In 1994 Brazil announced the Real Plan which resulted in a sharp decline in the rate of devaluation. The Plan ended in January 1999 with a 50 percent devaluation. Since then, and after an initial overshoot, the exchange rate floated but stayed on a mostly flat course, while inflation was surprisingly low. It should be noted, however, that balance-sheet effects have been negligible because the government had provided effective hedges against currency devaluation. This helps to explain the slight recession that followed this successful devaluation experiment.

with corresponding eigenvectors, v_i , $i = 1, 2$,

$$v_i = \begin{pmatrix} \lambda_i \\ 1 \end{pmatrix}. \quad (33)$$

As is well known, any solution of these differential equations can be expressed as follows:

$$\varphi_1 v_1 e^{\lambda_1 t} + \varphi_2 v_2 e^{\lambda_2 t}, \quad (34)$$

for some parameters φ_i , $i = 1, 2$.

The problem imposes initial and boundary conditions. The initial condition is $P_0 = 0$, and the boundary condition is that (π_T, P_T) lie on the stable branch associated with the high rate of devaluation that is expected to prevail starting at time T , $\bar{\epsilon}$. More specifically, by equations (28) and (3), and recalling that $A = 0$, the boundary condition requires $\pi_T = \lambda_1 P_T + \bar{\epsilon}$, where, by notational convention, $\lambda_1 = -\delta\sqrt{\theta\gamma}$, the stable eigenvalue of matrix (31). Hence, by (34),

$$\varphi_1 \lambda_1 e^{\lambda_1 T} + \varphi_2 \lambda_2 e^{\lambda_2 T} = \lambda_1 P_T + \bar{\epsilon}, \quad (35)$$

and

$$\varphi_1 + \varphi_2 = P_0 = 0. \quad (36)$$

Moreover, by equation (34),

$$\varphi_1 e^{\lambda_1 T} + \varphi_2 e^{\lambda_2 T} = P_T. \quad (37)$$

Hence, by (35) and (36),

$$\varphi_1 = \bar{\varepsilon} \frac{e^{\lambda_1 T}}{2\lambda_1}, \quad (38)$$

and, by (36) and (38),

$$P_T = \bar{\varepsilon} \frac{1 - e^{-2\delta\sqrt{\theta\gamma}T}}{2\delta\sqrt{\theta\gamma}}. \quad (39)$$

As expected, by (39), the larger is the rate of devaluation after the policy switch, $\bar{\varepsilon}$, the larger will be real currency appreciation at the time of the switch, T . Moreover, as the frequency of price revisions goes to infinity (i.e., $\delta \rightarrow \infty$), currency appreciation at switch time becomes nil. However, real currency appreciation increases with the degree of competition in the nontradables' sector (i.e., as $\alpha \rightarrow \infty$, implying, by (24), $\theta \rightarrow 0$). Actually, by (39),

$$\lim_{\theta \rightarrow 0} P_T = \bar{\varepsilon} T. \quad (40)$$

Thus, for example, in a highly competitive environment, the expectation that the rate of devaluation will rise from 0 to 20 percent per year after 6 months (i.e., $T = 1/2$) would result in a real currency appreciation of 10 percent (starting from full equilibrium) in the course of 6 months. This is not an insignificant appreciation considering that the expected policy switch is “in the cards” for many EMs (particularly in Latin America). Notice, incidentally, that the limit in expression (40) is independent of the average contract length, $1/\delta$.

Table 1. Incentive for Price Revision ($\gamma = 2$)

$(X/X^e - 1) \times 100$	Loss as share of ω	Loss as share of annual income for one-month duration contracts
-20	13	0.5
-15	7.7	0.3
-10	3.6	0.15
- 5	0.9	0.04
0	0	0
5	1	0.04
10	4.4	0.18
15	10.4	0.43
20	19.4	0.8

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