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Exchange Rate Pass-Through in Brazil

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Abstract

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In the last two years the *real* has undergone a large depreciation and the central bank has missed its inflation target in 2002 for the second year in a row. Inflation, however, has increased much less than the rate of currency depreciation and the pickup in inflation in the last quarter of 2002 raises the question of whether the exchange rate passthrough has finally risen. This paper argues that the passthrough in Brazil has fallen compared with estimates in other studies on earlier time periods, and remains low when compared with the passthrough in other Latin American countries. Indeed the passthrough is more comparable with that of G-7 countries—although in Brazil the effect on prices appears to be faster.

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I. INTRODUCTION

In the last two years the *real* has undergone a large depreciation, which is being passed through into domestic prices. The central bank targets consumer price inflation and has missed its end-year target in 2002 for the second year in a row. Inflation, however, has increased much less than the rate of depreciation of the *real*, which has lost 80 percent of its value against the dollar during 2001–02 (Figure 1). While, in the past, a substantial part of currency depreciation was absorbed by the economy without a strong impact on inflation, the pickup in inflation in the last quarter of 2002 raises the question of whether the exchange rate pass-through has finally risen, following such a period of almost continuous depreciation.

This paper argues that the exchange rate pass-through in Brazil has fallen when comparing current estimates with those of other studies on earlier time periods, and remains low when compared with the pass-through in other Latin American countries. Indeed the pass-through is more comparable with that of G-7 countries—although in Brazil the effect on prices appears to be faster. It is too soon to extrapolate from the evidence during the devaluation experienced at end-2002, but it appears that some factors have led to an increase in the pass-through, such as the sentiment that the depreciation was not temporary and a need for firms to recover margins, playing a key role in the recent pickup in inflation.

The paper is organized as follows. The next section sets the stage by presenting some stylized facts on the relation between prices, the exchange rate, and economic activity in Brazil. Section III reviews the literature and outlines the factors that have been found to explain incomplete exchange rate pass-through in different countries. Section IV investigates empirically the dynamics of the exchange rate pass-through in Brazil and compares the results with earlier studies and cross-country evidence. Section V summarizes the conclusions.

II. STYLIZED FACTS

To analyze the degree of pass-through of currency depreciation to domestic prices, it is first necessary to decide which indicator of the price level is relevant for use. The headline consumer price index (IPCA) is of clear interest because it is the measure of inflation targeted by the central bank and is the index that matters to determine monetary policy. However the change in the broader general price index (IGP-DI) is a more accurate measure of inflation. In addition, it is useful to assess the degree of pass-through in different sectors of the economy, in particular to prices set early in the distribution chain, such as those summarized in the wholesale price index (IPA), as well as to tradable and nontradable goods prices (respectively, 40 percent and 33 percent of the IPCA). The remainder of the IPCA index consists of prices administered by the government (e.g., public transport and fixed phone line prices) or managed by contract (mostly energy prices). Because this puts these prices outside

central bank control, it is important to anticipate their sensitivity to an exchange rate shock to calibrate monetary policy.[1]

Figure 1. Brazil: Inflation and depreciation, 2001-02
(Dec 2000=100)
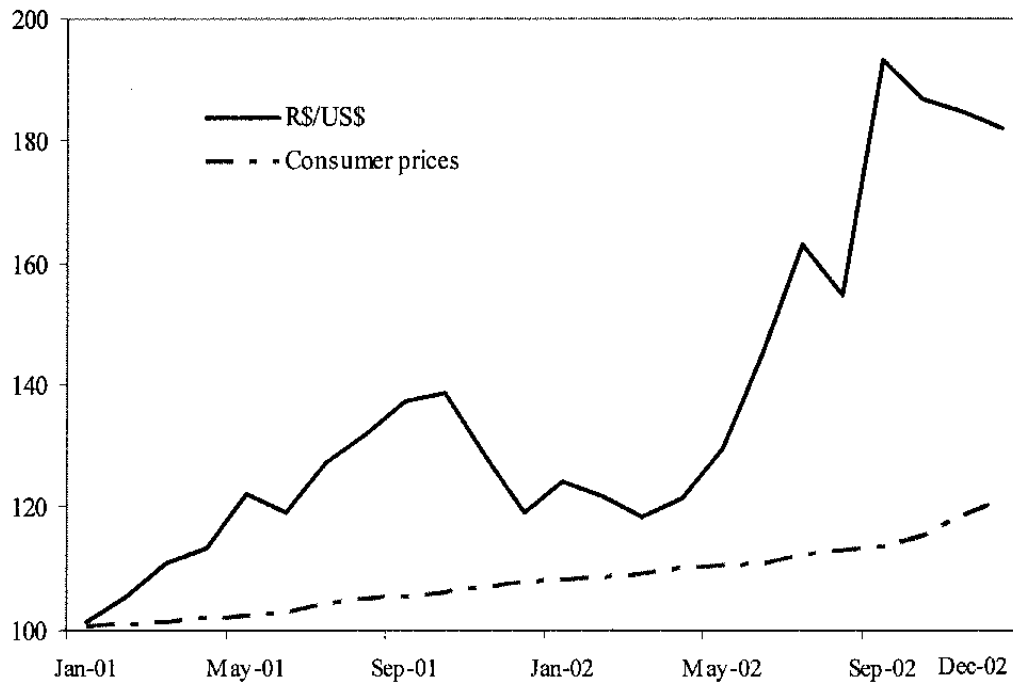
Source: Central Bank of Brazil.

There are some clear stylized facts in the behavior of these prices.

- Inflation has been much more stable than the change in the exchange rate and price changes are difficult to relate to changes in the exchange rate (Figure 2A).

- Prices of wholesale, tradable, and administered goods show a more rapid impact of a depreciation due to the high import content of these indices.

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[1] The consumer price index (IPCA) and its components (tradable, nontradable, administered and free prices) are produced by the Brazilian statistical institute (IBGE). The wholesale price index (IPA) and general index (IGP-DI) are produced by the Getulio Vargas Foundation (FGV).

Figure 2. Brazil: Depreciation and Inflation, 1999:07-2002:12

2A. Depreciation and inflation
(12-month percent change)

- IGP-DI
- IPA
- IPCA
- Monitored
- Tradables
- Nontradables
- R$/US$ (right axis)

2B. Fluctuations around trend
(percent deviation from trend)

- R$/US$
- IPCA
- IPA
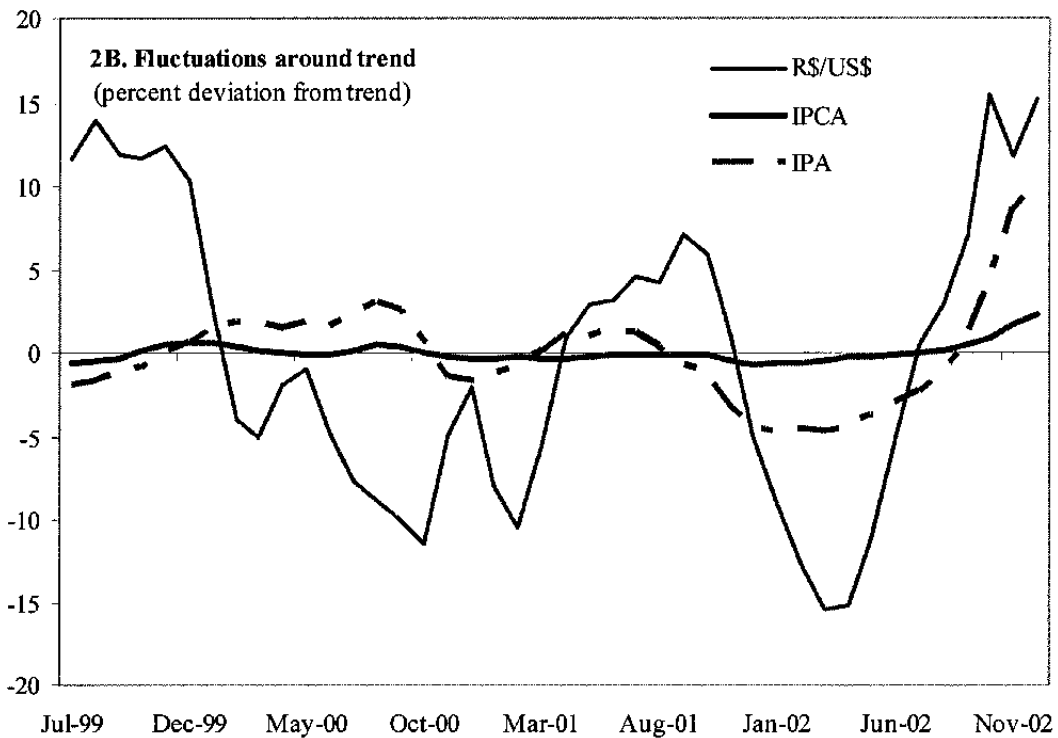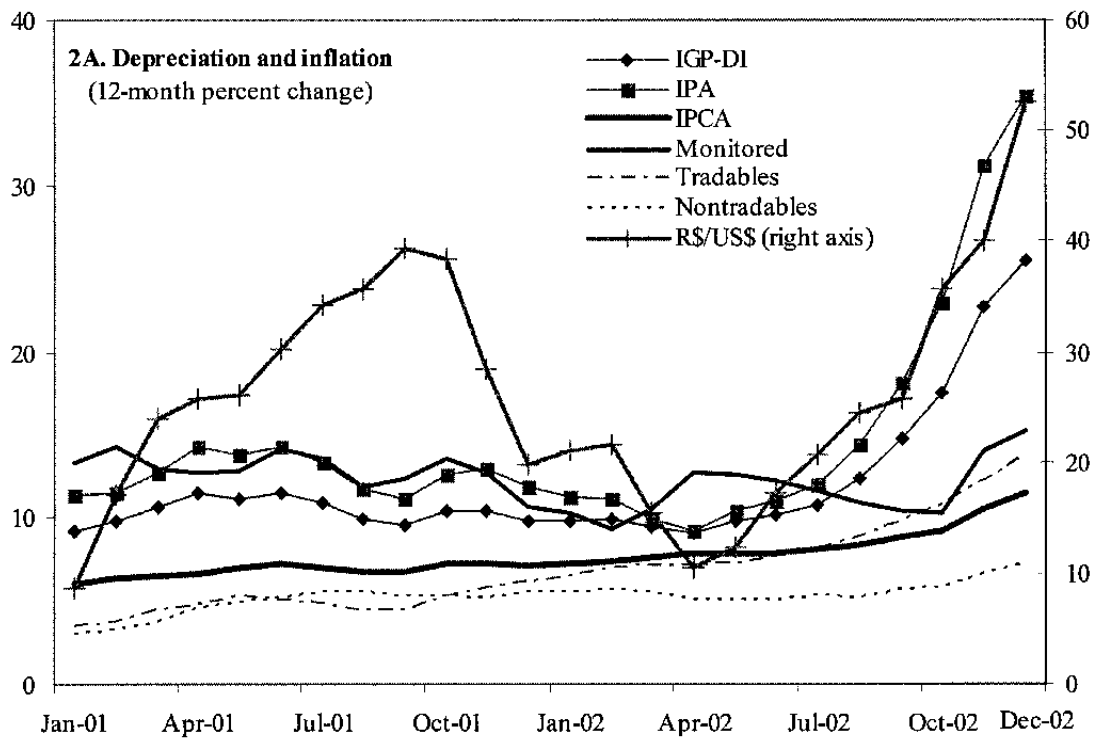
Sources: FGV, IBGE, Central Bank of Brazil; and Fund staff calculations.

- Detrending both prices and the exchange rate using a Hodrick-Prescott filter shows that exchange rate volatility is about 3 times larger than that of wholesale prices and 15 times larger than of consumer prices (Figure 2B and Table 1).

- Exchange rate fluctuations are found to lead price fluctuations, by one to two months in most cases, independently of the type of index considered, although fluctuations in tradable goods remain correlated with exchange rate movements that took place up to five months in the past.

Table 1. Behavior of Exchange Rate and Prices (Deviations from Trend), 1997:07–2002:12								
	Volatility relative to E's (percent)	Cross correlation of E(t) with X (t+j), with j =						
		0	1	2	3	4	5	6
Variable X:								
IPCA	6.6	**0.45**	0.43	0.40	--	--	--	--
Administered prices	7.2		0.32	**0.34**	--	--	--	--
Free prices	9.5	**0.57**	0.55	0.52	--	--	--	--
Tradables	17.1	0.42	0.49	**0.55**	0.46	0.36	--	--
Nontradables	7.1	0.36	--	--	--	--	--	--
Wholesale prices	35.6	**0.44**	0.42	0.37	--	--	--	--
General price index	27.6	0.53	**0.56**	0.52	0.37	--	--	--

Note: E is the R$/US$ exchange rate. Variables are in deviations from trend (Hodrick-Prescott filtered logarithms of deseasonalized data). The table only reports significant coefficients (0.30 is the 5 percent significant level). No lead coefficient was significant at 5 percent significance.

Source: IMF staff calculations.

The overall impression from the data is that, until recently, there appears to have been little response of consumer price inflation to exchange rate volatility. In particular, exchange rate deviations from trend do not lead to equivalent domestic price adjustments. This suggests the possibility that prices are more sensitive to deviations of the exchange rate that are perceived as a more permanent, long-term trend.

Most recent data show a clear pickup in inflation associated with a sharp acceleration in currency depreciation. However, it is unclear whether this reflects the effect of the large depreciation with an unchanged pass-through or a structural shift in the way domestic price setters react to currency depreciation. A simple calculation would suggest that the average ratio of inflation to changes in the exchange rate has not increased during the course of the year (Table 2).

Table 2. Static Pass-through (percent)		
	IPCA	IPA
QI-02	111.2	141.7
QII-02	34.9	49.8
QIII-02	19.6	44.8
QIV-02	23.7	66.9
Percent change in inflation relative to percent change in the exchange rate.		

Source: IMF staff calculations.

III. FINDINGS FROM THE LITERATURE

The literature proposes several arguments to understand why the pass-through of currency depreciation to prices has been smaller than expected in Brazil and suggests avenues for empirical work to assess whether this should remain so or not:

- The pass-through tends to be correlated with the degree of openness (McCarthy, 1999), such that a less open economy—like Brazil, where the sum of exports and imports is only 30 percent of GDP—should see a smaller impact of currency depreciation on prices.

- The pass-through tends to be incomplete. In particular, large devaluations are not followed by the high rates of inflation that would be consistent with purchasing power parity. There are several reasons cited for this:

  - The share of nontradables in the CPI is usually underestimated since tradable prices include distribution costs which are largely unaffected by a devaluation. This dampens the effect of exchange rate changes on consumer prices (Burstein *et al.*, 2001 and 2002).

  - Prices, including those of imports, may be sticky in local currency (Betts and Devereux, 2000). This blocks the transmission of exchange rate changes to domestic prices in the short run.

  - More expensive imported goods lead to a "flight from quality" and a substitution toward locally produced goods (Burstein *et al.*, 2002).

- The pass-through tends to be procyclical, falling when the economy enters a recession, as firms compress margins rather than pass on exchange rate changes (Leiderman and Bar-Or, 1999; Goldfajn and Werlang, 2000).

IV. A VECTOR AUTOREGRESSION ANALYSIS OF THE PASS-THROUGH

It is possible that if a depreciation is prolonged, as has been the case in Brazil, a pent-up pass-through may result in a sudden increase in inflation that lags the depreciation. This would suggest that the dynamic structure underlying the interaction between economic activity, the exchange rate, and prices is important. To capture these dynamics, a recursive VAR is estimated following McCarthy (1999), during the period that the *real* was floating and inflation targeting was in place.[2] To remove seasonal patterns, variables were

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[2] The availability of high-frequency data made it possible to estimate the system over a relatively limited time period (thus providing results of greater relevance to the present time) without having to worry about sample size problems.

deseasonalized using the Tramo-Seats procedure. The VAR uses monthly data from July 1999 to December 2002 and includes the exchange rate of the *real* per U.S. dollar, domestic prices, a proxy for supply shocks and an aggregate demand indicator. Supply shocks are identified by oil prices expressed in domestic currency. Industrial production identifies aggregate demand.[3] Several domestic price indices are examined to capture the effect of a depreciation on wholesale and consumer prices, tradable and nontradable goods prices, and freely determined and administered prices. This approach also allows a disaggregation of the impact of exchange rate shocks on different components of the IPCA.

Estimation

Given that unit root tests show all variables to be nonstationary in levels and that Engle and Granger tests reject the hypothesis of cointegration between the nonstationary variables, the VAR is estimated with all variables in log-differences. Differencing is done month to month to preserve as much information as possible on the monthly pattern of interaction between endogenous variables given the desire to limit the estimation to a short, recent time period. Ordering of the variables to achieve VAR identification is determined using Granger causality tests. Variables found to be the most exogenous in the system are ordered first, followed by variables likely to be affected contemporaneously by shocks to the other variables. Oil prices, industrial production, and the exchange rate are always found to be the most exogenous variables and thus ordered before the price variables. Among the first group of variables, supply and demand shocks are assumed to be independent from the exchange rate at date t and placed first (i.e., not to be contemporaneously affected by an exchange rate shock, but themselves able to affect the exchange rate). Changing the ordering of variables in each group does not affect the results. Likelihood ratio tests suggest the inclusion of two lags for each variable.[4] The estimated system can thus be represented as follows:

$$\pi_t^{oil} = a_1 \pi_{t-1}^{oil} + a_2 \pi_{t-2}^{oil} + u_t^{oil}$$

$$\Delta Y_t = b_1 \Delta Y_{t-1} + b_2 \Delta Y_{t-2} + b_3 u_t^{oil} + b_4 u_t^{Y}$$

$$\Delta e = c_1 \Delta e_{t-1} + c_2 \Delta e_{t-2} + c_3 u_t^{oil} + c_4 u_t^{Y} + c_5 u_t^{e}$$

$$\pi_t^{index} = d_1 \pi_{t-1}^{index} + d_2 \pi_{t-2}^{index} + d_3 u_t^{oil} + d_4 u_t^{Y} + d_5 u_t^{e} + u_t^{index}$$

where Δ is the first difference operator, u is the innovation in the superscript variable, Y is industrial production, and π is inflation in a particular index (CPI, WPI, general, administered, free, traded goods, non-traded goods prices).[5]

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[3] The series for industrial production is from the IBGE; oil prices are the average of U.K. Brent, Dubai, and West Texas Intermediate and taken from the IMF's IFS database; the sources for the price indices are cited in footnote 1.

[4] The lag specification is found to remove serial correlation in the residuals, and the VAR model can be estimated using OLS.

[5] Not all price indices are included in the same VAR given degrees of freedom constraints and because some indices are aggregates of others (for example, the IPCA is a weighted average of administered and free price indices). Hence, four VARs are estimated, each

Impulse response functions

The estimated VAR is used to simulate impulse response functions that illustrate the impact over time of a temporary shock to one variable on the others, allowing for the changes in the lagged variables to feed back on the shocked variable. The results are as follows:

- A one-standard deviation shock to the exchange rate change (an increase in the rate of depreciation of approximately 2.3 percent) has little effect on IPCA inflation (Figure 3). The acceleration in inflation peaks toward the end of the quarter in which the shock takes place, and converges back to zero after six months.

- Wholesale price inflation (IPA) shows a faster and much larger response to an exchange rate shock, peaking in the month following the shock and remaining significantly higher for about eight months after the shock.

- The general price index (IGP-DI) summarizes these two responses, with general price inflation responding quickly following the exchange rate shock but with an impact that is relatively short-lived (it returns to its pre-shock level after two quarters).

- Tradable goods prices are, as expected, the most sensitive to exchange rate shocks; their response is similar to that of wholesale prices of which they are the main component.

- Free price inflation follows a similar pattern to that of tradables inflation, although the response is slightly weaker.

- The effect of an exchange rate shock on nontradable goods prices is small but persistent: the adjustment continues 12 months after the initial impact. This is consistent with the idea that nontradable prices are affected in the second round by exchange rate changes.

- Administered prices react to an exchange rate shock faster than do free prices, but their response is not significant after a quarter.

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representing a different degree of aggregation in the price variables. A first model estimates the pass-through to general price inflation; a second one to consumer and wholesale prices (with the IPCA placed last in the distribution chain); the third specification decomposes the IPCA into free and administered price indices; and the last one disaggregates free prices into traded and nontraded goods prices. For comparability, all exchange rate shocks are one standard error (approximately 2.3 percent).

Figure 3. Brazil: Response of Different Prices to an Exchange Rate Shock
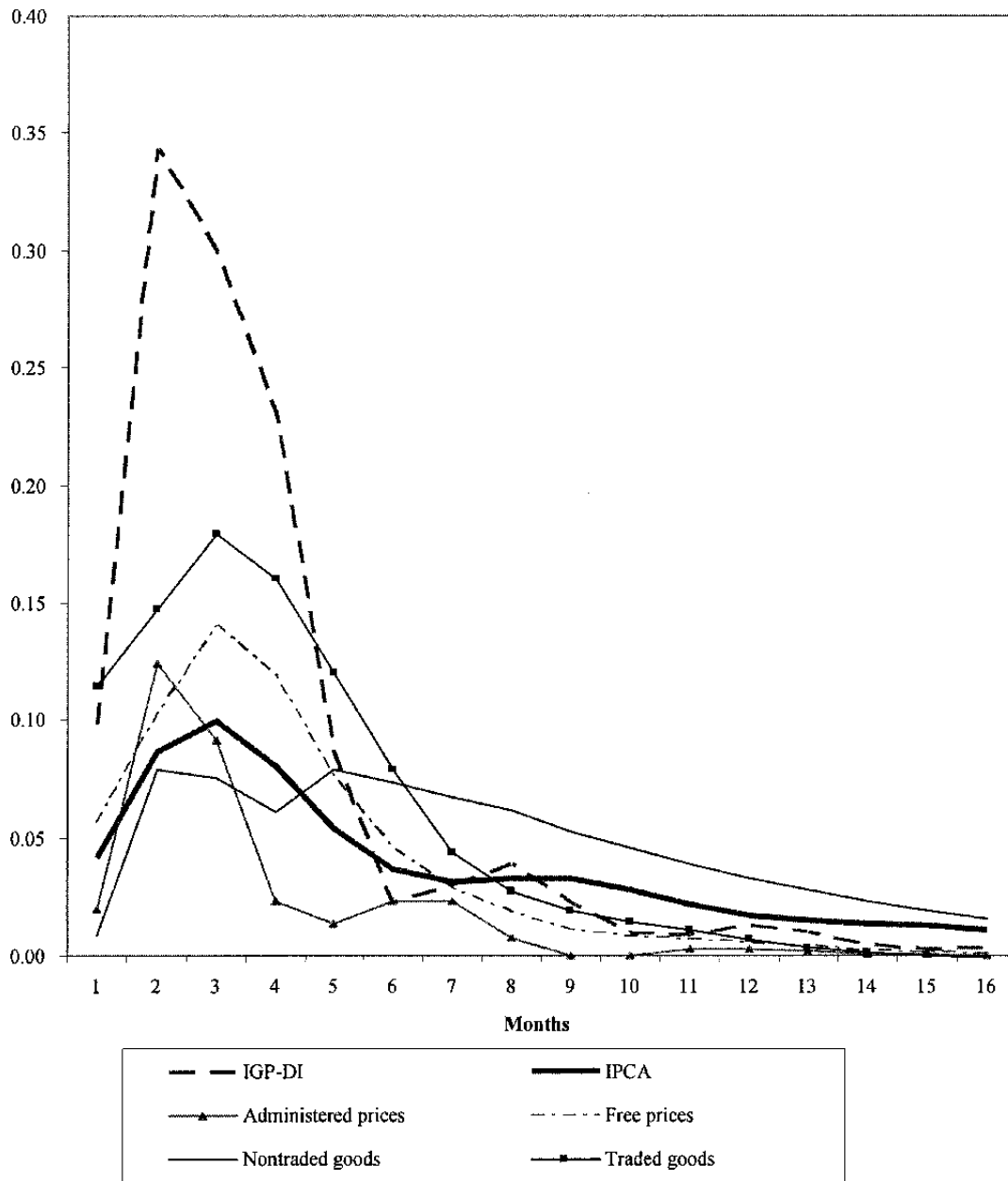
Source: Fund staff estimates.

- There does not appear to be a strong relationship between the exchange rate and administered prices. Although inflation in government-administered prices and prices managed by contracts has been higher than consumer price inflation, adjustments to these prices are generally delinked from current shocks.[6]

In summary, the data show that the reaction of prices, excluding tradables, to an exchange rate shock is modest. After two quarters, the increase in inflation is close to zero.

Pass-through estimates

Cumulative pass-through coefficients are derived from the impulse response functions as:

$$PT_{t,t+j} = \sum_{j=1}^{T} \Delta P_{t,t+j} \Big/ \sum_{j=1}^{T} \Delta E_{t,t+j}$$

where ΔP_{t+j} is the cumulative change in the price level j months after the shock and ΔE $t+j$ is the cumulative exchange rate depreciation over the same period.

The pass-through estimates derived from the model are summarized in Table 3.

Since the model is expressed in first differences, the impulse responses are for monthly inflation. It is necessary to plot the cumulative impulse responses to trace out the response profile for the price level. The pass-through coefficients, therefore, show the model's predicted adjustment of prices to an exchange rate shock after accounting for disturbances of the other endogenous variables in the model. The following results are derived from this exercise:

- The exchange rate shock feeds through to consumer prices gradually, with the pass-through increasing from 6 percent in the quarter when the shock takes place to 17 percent after a year. Given the standard errors on the estimated coefficients, the 12-month pass-through ranges between 15 percent and 18 percent with a 95 percent confidence interval.

- Wholesale prices react quite differently, with as much as a third of the shock reflected in the first quarter. All the shock feeds through to prices after a year: within a 95 percent confidence interval, the pass-through is between 93 percent and 124 percent at this time. This is consistent with the fact that about 90 percent of the

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[6] For example, domestic petroleum prices are reviewed every two weeks in light of development in international prices, but there is no threshold for automatic adjustment. In addition, these prices carry a specific tax (Cide) making up a third of the retail price, which dampens the link between the exchange rate and the retail price of oil products.

components of the wholesale price index are tradables.[7]

Table 3. VAR Estimates of the Pass-Through (percent)						
	General Prices	Wholesale Prices	Consumer Prices	Free Prices	Administered Prices	Tradable Prices	Nontradable prices
Horizon:							
1M	8	12	2	3	1	5	0
3M	27	34	6	7	3	12	4
12M	53	120	17	15	5	15	12
16M	60	139	20	15	5	15	12
Long term	71	165	23	15	5	15	13

- The pass-through remains low when measured relative to general price inflation. IPA inflation rises by about half the exchange rate depreciation after a year. Even after three years, only 70 percent of the depreciation is reflected in prices.

The ranking of pass-through elasticities—highest for wholesale prices, followed by tradables, free prices, and the aggregate consumer price index—suggests that shocks to the exchange rate have a successively smaller impact as one moves down the distribution chain: after a year, only about 15 percent of the exchange rate shock has passed to consumer, free and nontradable goods prices (Figure 4).[8] The speed of adjustment also varies among retail price indices, with tradables prices being affected the quickest. After a year, though, consumer, free, and nontradable goods prices have all caught up. The incomplete pass-through, as well as the gradual increase in nontradables inflation, may well be evidence of a "flight from quality" by consumers away from imports to lower-quality local substitutes. The evidence would also be consistent with the existence of sticky prices in domestic currency, perhaps the result of New Keynesian-type menu costs or temporary margin compression by suppliers.

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[7] The cumulative pass-through increases beyond 100 percent of the change in the exchange rate, although at a decelerating rate after a year, probably the result of second-round effects of the exchange rate change.

[8] Note that the econometric analysis is consistent with the IPCA pass-through as a weighted average of the pass-through coefficients to the disaggregated price indices.

Figure 4: Exchange rate passthrough across price baskets
(percent)
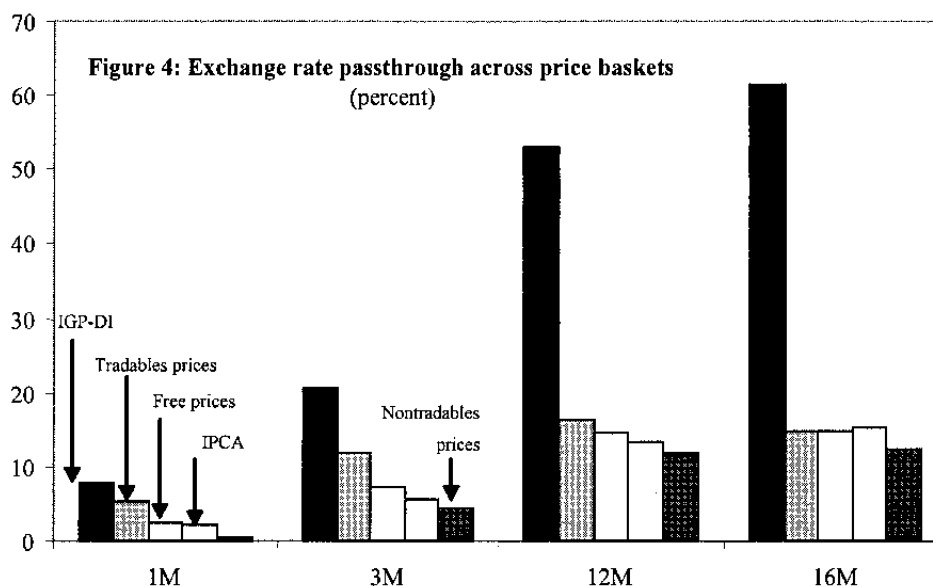
Source: Fund staff estimates.

The impact of the exchange rate on consumer price inflation in Brazil is low by international standards (Table 4). It is much lower than in Latin American countries as a group (Goldfajn and Werlang, 2000) and, although the short-term pass-through is larger in Brazil than that for G-7 countries (Choudri *et al.*, 2002), the one-year pass-throughs are comparable.

Table 4. International Comparison of Pass-Through (Percent)			
	Consumer Prices		
	VAR	Latam	Non-U.S. G-7
Horizon:			
1M	2	10	...
3M	6	20	2
12M	17	69	11
16M	20	124	...
Long term	23	...	19

The table reports the cumulative share of a 1 standard deviation depreciation shock passed on to prices at different horizons.

Note: Long term is the 3-year figure for Brazil and 2.5 year one for non-U.S. G-7 countries. VAR refers to the estimates obtained in this paper.

Sources: Fund staff estimates; Goldfajn and Werlang (2000) for the Latin American panel; and Choudri *et al.* (2002) for non-U.S. G-7.

V. TESTING FOR A CHANGE IN THE PASS-THROUGH IN RECENT DATA

Currency depreciation has been driving up the price level with a lag, particularly in the fourth quarter of 2002 when cumulative inflation grew about 7 percent from the previous quarter, despite the contemporaneous currency appreciation. This raises the question of whether the size of the pass-through increased in Brazil toward the end of 2002 or whether the rise in inflation reflected a delayed but proportional adjustment to the earlier exchange rate depreciation. Market inflation expectations, as surveyed weekly by the central bank, rose steadily during that period despite a 700 basis point hike in the overnight policy rate. And consumers and investors have been redirecting their—weak—demand toward less expensive, locally produced goods, whose prices have begun to rise too. Identifying whether the pass-through has increased would provide a useful input to guide the monetary policy response to the recent depreciation.

Pass-through estimates reported in other studies of the pass-through in Brazil on earlier periods have been much higher than those obtained in this paper (Table 5). For example Schwartz and Rabanal (2001) estimated that during 1995–2000, almost 80 percent of exchange rate shocks was passed through to consumer prices after 12 months, about four times more than in the recent sample examined here.[9] Kfoury (2001) uses a more structural approach, based on an open economy version of the Phillips curve, and finds that the pass-through declined significantly after the floating of the *real*, but to levels that are much larger, at least in the short term, than those found here.

Table 5. Has the Pass-Through Increased Over Time? (Percent)					
	Wholesale Prices		Consumer Prices		
	This paper Jul-99-Dec-02	Schwartz *et al.* Jan-95-Sept-00	This paper Jul-99-Dec-02	Schwartz *et al.* Jan-95-Sept-00	Kfoury 1998:Q1-2000:Q4
1M	27	11	2	5	12
3M	53	60	6	48	13
12M	60	88	17	79	13

The table reports the cumulative percentage share of a 1 standard deviation depreciation passed on to inflation over a horizon of 1 to 12 months.

Sources: Fund staff estimates; Schwartz and Rabanal (2001); Kfoury (2001).

The experience is too recent to re-estimate here the pass-through equations only in the last few months of 2002. Rather, we test for the presence of a structural break in the data to answer this question. Chow's test uses the pass-through estimates obtained on the earlier

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[9] Although it should be noted that their sample period includes a structural break in the exchange rate and monetary regime and a large devaluation, captured through the inclusion of a dummy in the estimation.

period to predict what the pass-through should be on the later period. It then compares these forecasts with the actual estimates obtained from the whole sample estimation. The F test statistics rejects the null hypothesis of no structural break in the pass-through coefficient in the inflation equation (although the result is less decisive when using the chi-square statistics, when it is true only with a 10 percent probability of error, see Table 6). Coefficient stability tests also weigh in favor of a change in the pass-through coefficient toward the end of 2002. The one-step ahead forecast test, which estimates repeatedly a recursive least squares equation of inflation and predicts the next value, computing the forecast error at each step until all the sample points have been used, shows an increase in the pass-through around October-November 2002 (Figure 5).[10] These tests suggest that there may well have been a change in the pass-through, although it is still too early to provide a definitive answer.

Figure 5: One-step ahead stability test.
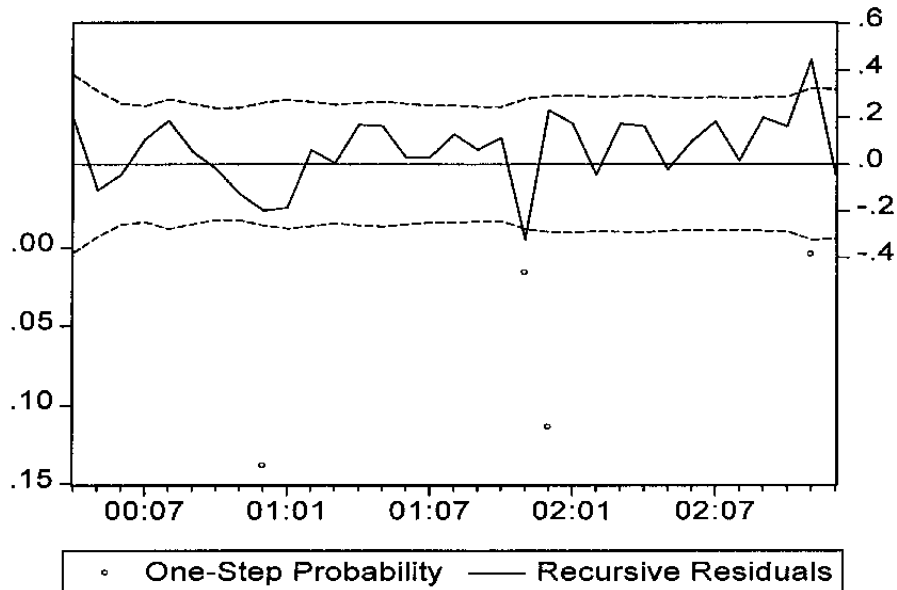
Note: the residuals and standard deviation bands are measured on the right axis.
The lower portion of the left axis shows the probability values for sample
points where the hypothesis of parameter consistency is rejected at the 5, 10,
and 15 percent levels.
The sample points with p-values less 5 percent can be interpreted as residuals
significantly different from zero.

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[10] Residuals outside the standard error bands suggest instability in the parameters of the equation. The forecast error at each date is the difference between the actual observation and the model's fitted prediction. A positive error means that the actual variable is higher than expected.

Table 6. Structural Break Test			
Chow Forecast Test: Some evidence of a structural break from 2002:09 onward.			
F-statistic	3.35	Probability	0.0226
Log likelihood ratio	15.96	Probability	0.0031
The 95 percent significance level for the F test is 2.66.			
Source: Fund staff calculations.			

VI. CONCLUSION

This paper finds that the significant trend depreciation in Brazil in 2001–02—the result of a series of domestic and external shocks—has not been followed by a large increase in inflation due to a consistently low pass-through. In particular,

- The pass-through to consumer prices is estimated to be limited but rapid, ending after two quarters. Model estimates suggest that about 6 percent of the exchange rate shock passes to consumer prices in the same quarter as the shock occurs and 17 percent after a year, with most of the shock likely absorbed along the supply chain.

- The impact on the wholesale price index, which contains a high percentage of tradable goods, is much larger and occurs more rapidly, with about a third of the initial exchange rate shock transmitted to prices in the same quarter, and about 100 percent in the course of a year.

- General price index reacts, in a given year, to about one-half of the change to the exchange rate.

The explanation for the limited pass-through is likely related to a combination of factors, which include:

- the depressed level of economic activity and firms' preference for compressing margins to preserve business volumes rather than pass on higher costs to consumers (and their ability to do so after a year of historically high growth in 2000);[11]

- the availability of domestically produced goods as substitutes for imports for import-users;

- the slow adjustment of nontradable prices and wages; and

- the sentiment that the depreciation was temporary.

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[11] This would argue, however, for a nonlinear pass-through relationship (with the impact of larger depreciations being more than proportionally stronger than that of small exchange rate changes) rather than a low pass-through coefficient.

However, these factors would argue that a rise in the pass-through should now be expected. After some improvement in market sentiment at the start of 2003, global uncertainties have partially reversed gains in currency and the *real* has started depreciating again. Inflation expectations have been rising and there may be an increased perception that the *real* depreciation is not a temporary phenomenon. In addition, it may be difficult for firms to continue compressing margins. Indeed, the large difference encountered in this paper between the pass-through to wholesale prices and that to consumer prices suggests that, up to now, much of the absorption of exchange rate shocks has taken place somewhere along the supply chain, and must have led to a significant compression of profit margins.

Tests for the existence of a structural break point to an increase in the pass-through toward the end of the sample. However it is too early to make definitive statements on this point: the depreciation shock hit toward the second half of 2002 and post-shock data are limited. After such period of almost continuous depreciation, it is possible that going forward, further exchange rate shocks will translate into a higher share of the exchange rate depreciation being passed on to prices. While there is some evidence that the pass-through has been increasing, it is not yet possible to empirically verify or quantify this change.

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