International Pricing in New Open-Economy Models

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R ecent developments in open-economy macroeconomics have progressed under the paradigm of nominal price rigidities, where monetary disturbances are the main source of fluctuations. Following developments in closed-economy models, new open-economy models have combined price rigidities and market imperfections in a fully microfounded intertemporal general equilibrium setup. This framework has been used extensively to study the properties of the international transmission of shocks, as well as the welfare implications of alternative monetary and exchange rate policies.

Imperfect competition is a key feature of the new open-economy framework. Because agents have some degree of monopoly power instead of being price takers, this framework allows the explicit analysis of pricing decisions. The two polar cases for pricing decisions are *producer-currency pricing* and *local-currency pricing*. The first case is the traditional approach, which assumes that prices are preset in the currency of the seller. In this case, prices of imported goods change proportionally with unexpected changes in the nominal exchange rate, and the law of one price always holds.[1] In contrast, under the assumption of local-currency pricing, prices are preset in the buyer's currency. Here, unexpected movements in the nominal exchange rate do not affect the price of imported goods and lead to short-run deviations from the law of one price.

[1] The law of one price states that, absent barriers to trade, a commodity should sell for the same price (when measured in a common currency) in different countries.

Empirical evidence using disaggregated data suggests that international markets for tradable goods remain highly segmented and that deviations in the law of one price are large, persistent, and highly correlated with movements in the nominal exchange rate, even for highly tradable goods. Moreover, there is strong evidence that the large and persistent movements that characterize the behavior of real exchange rates at the aggregate level are largely accounted for by deviations in the law of one price for tradable goods.

In this article I make use of a simplified version of a two-country model where the two markets are segmented, allowing firms to price discriminate across countries, and where prices are preset in the consumer's currency. This model generates movements in the real exchange rate in response to unexpected monetary shocks, which are a result of the failure of the law of one price for tradable goods. I then compare this model to a version in which prices are preset in the producer's currency and examine the implications of these two alternative price-setting regimes for several key issues.

The price-setting regime determines the currency of denomination of imported goods and the extent to which changes in exchange rates affect the relative price of imported to domestic goods and the international allocation of goods in the short run. That is, different pricing regimes imply different roles for the exchange rate in the international transmission of monetary disturbances. As we shall see, this assumption has very striking implications for several important questions, namely real exchange rate variability, the linkage between macroeconomic volatility and international trade, and the welfare effects of alternative exchange rate regimes, among others.

While generating deviations from the law of one price that are absent from models assuming producer-currency pricing, the assumption of local-currency pricing still leaves important features of the data unexplained. The key role of this assumption in the properties of open-economy models suggests that it is necessary to keep exploring the implications of alternative pricing structures in open-economy models.

In Section 1, I review the empirical evidence on the behavior of real exchange rates and on international market segmentation and pricing. In Section 2, I present the model with local-currency pricing and explore the main implications of this pricing assumption. The final section concludes.

1.   SOME EVIDENCE ON REAL EXCHANGE RATES

I first review some empirical evidence on the behavior of real exchange rates using aggregate data. I then turn to a review of the evidence on the sources of movements in real exchange rates.

Real Exchange Rates and PPP

The real exchange rate between two countries represents the relative cost of a common reference basket of goods. For two countries, say the United States and Japan, the real exchange rate is given by

$$\frac{P_{US}}{e\,P_{JP}},$$

where P_{US} and P_{JP} represent the American and Japanese price levels (measured in terms of dollars and yen, respectively) and where e denotes the nominal exchange rate (defined as the dollar price of one yen).[2]

The theory of purchasing power parity (PPP) predicts that real exchange rates should equal one, or at least show a strong tendency to quickly return to one when they differ from this value. The fundamental building block of PPP is the law of one price: due to arbitrage in goods markets, and absent barriers to trade, similar products should sell in different countries for the same price (when converted in the same currency). Large international price differentials would be only temporary, as profit-maximizing traders would quickly drive international goods prices back in line. Therefore, if arbitrage in goods markets ensures that the law of one price holds for a sufficiently broad range of individual goods, then aggregate price levels (when expressed in a common currency) should be highly correlated across countries.[3]

Because aggregate prices are reported as indices rather than levels, most empirical work has tested the weaker hypothesis of relative PPP, which requires only that the real exchange rate be stable over time.[4] Figure 1 shows the log changes in the CPI-based dollar-yen real and nominal exchange rates and the relative price level. In this figure, which is typical for countries with floating exchange rates and moderate inflation, it clearly stands out that short-run deviations from PPP are large and volatile. In the short run, movements in the real exchange rate mimic those in the nominal exchange rate, with no offsetting movements in the relative price level. Not surprisingly, early empirical work based on simple tests of short-run PPP produced strong rejections of this hypothesis for moderate inflation countries.[5] However, these studies did not allow for any dynamics of adjustment to PPP and therefore did not address the validity of PPP as a medium- or long-run proposition.

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[2] Suppose that the United States and Japan have the same price levels when measured in their respective currencies (for example, $P_{US} = P_{JP} = 1$) and that the nominal exchange rate is two (that is, two dollars are required to buy one yen). Then, the Japanese price level is two when measured in dollars and the real exchange rate between the United States and Japan is 0.5.

[3] For a thorough exposition of the evolution of the PPP theory of exchange rates, see Humphrey and Keleher (1982, chapter 11).

[4] In other words, relative PPP requires only that changes in relative price levels be offset by changes in the nominal exchange rate.

[5] See, for example, Frenkel (1981) or Krugman (1978).

**Figure 1 Nominal and Real Exchange Rates and Relative Price
Changes between Japan and the United States**
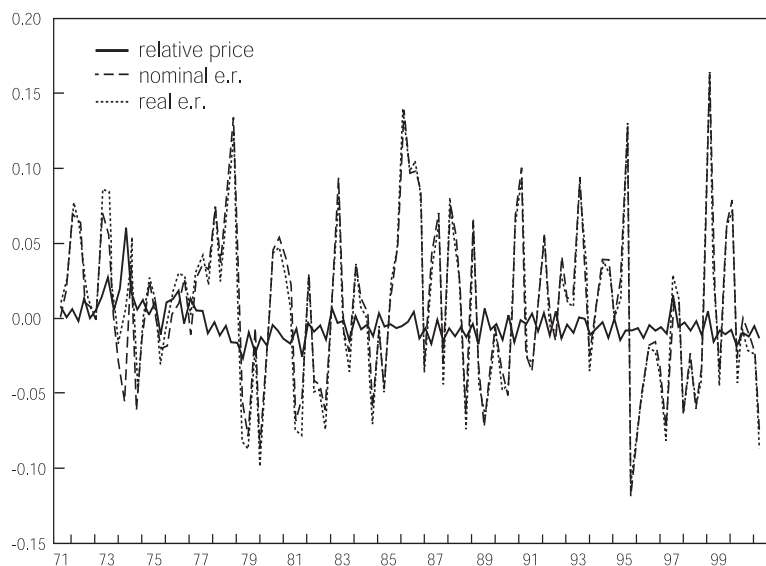
Sources: Federal Reserve Board of Governors, Bloomberg, and IMF International Financial Statistics

The conventional explanation for the failure of short-run PPP is the presence of nominal price rigidities. If the short-term volatility of nominal exchange rates were due mostly to monetary and financial disturbances, then nominal price stickiness would translate these disturbances into short-run fluctuations in the real exchange rate. If this were true, however, we should observe a substantial convergence to PPP in one to two years, as the adjustment of prices and wages takes place. Purchasing power parity, therefore, would be reestablished in the medium to long run.[6]

An extensive body of empirical literature has tested the hypothesis of long-run PPP by looking at the mean-reverting properties of real exchange rates. As is well known, it has proved rather difficult to find evidence supporting convergence of real exchange rates to PPP even in the long run.[7]

Most earlier empirical studies, which used only post-Bretton Woods data, found it difficult to reject the hypothesis that bilateral real exchange rates for

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[6] See Stockman (1987) for an alternative, equilibrium view of exchange rates.

[7] For a survey of this literature and a more complete list of references, see Froot and Rogoff (1995) or Rogoff (1996).

industrialized countries follow a random walk under floating exchange rates.[8] But if PPP deviations are very persistent, then it may be difficult to distinguish empirically between a random walk model and a slow mean-reversion model for the real exchange rate, especially when this variable is highly volatile. As shown in Frankel (1986), the post-Bretton Woods period may simply be too short to reliably reject the random walk hypothesis. To overcome this problem of low power in tests of the random walk hypothesis, Frankel used an extended data set (annual data for the dollar-pound exchange rate from 1869 to 1984) and rejected the random walk model in favor of a mean-reverting model for the real exchange rate. His point estimate for the rate of decay of real exchange rate deviations was 14 percent per year, which implies a half-life of PPP deviations of 4.6 years. Other studies that test convergence to PPP using long-horizon data sets tend to find values for the half-life of PPP deviations between three to five years.[9]

An alternative way to increase the power of unit root tests is to expand the number of countries in the sample and to perform panel tests of convergence to PPP. Frankel and Rose (1996), for example, use a panel set of annual data from 1948 to 1992 for 150 countries. They estimate half-lives for PPP deviations of about four years. Other studies using panel data sets report similar estimates. Interestingly, these estimates are also similar to those obtained using long-time series data sets.

In brief, studies using aggregate data provide strong evidence that deviations from PPP are highly volatile and persistent. Consensus estimates suggest that the speed of convergence to PPP is roughly 15 percent per year, implying a half-life of PPP deviations of about four years. As we shall see next, a look at disaggregated data will provide us with a much richer analysis of the sources of PPP deviations.

The Law of One Price: Market Segmentation and International Pricing

As I pointed out earlier, the idea underlying PPP is that the law of one price holds for a wide range of individual goods. It has long been recognized, however, that even for highly tradable goods and at different levels of aggregation,

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[8] Typically, the real exchange rate, q_t, is assumed to follow a linear $AR(1)$ specification,

$$q_t = \rho q_{t-1} + \epsilon_t,$$

where $\epsilon_t \sim N\left(0, \sigma^2\right)$. This specification means that the adjustment of PPP deviations is both continuous and of constant speed, regardless of the size of the deviation. Given this specification, the *convergence speed* is given by $\lambda = 1 - \rho$ and the *half-life of deviations* is given by $H = \frac{\ln 0.5}{\ln \rho}$.

[9] Mussa (1986) demonstrates that real exchange rates tend to be much more volatile under floating than under fixed exchange rate regimes. Therefore, these long-horizon data sets mix data from different regimes, which exhibit different properties for the real exchange rate. See Lothian and Taylor (1996) for a response to this criticism.

deviations in the law of one price are large, persistent, and highly correlated with movements in the nominal exchange rate.[10]

One possible explanation for the failure of the law of one price is that international markets are segmented by physical distance, like different markets within a country. Engel and Rogers (1996), however, show that both the distance and the physical border between countries are significant in explaining the variation in prices of similar goods across different U.S. and Canadian cities. They find that price dispersion is much higher for two cities located in different countries than for two equidistant cities in the same country. In fact, the effect of the border is estimated to be equivalent to a distance of 1780 miles between cities within one country. Engel and Rogers also show that nominal price stickiness accounts for a large portion of the border effect, suggesting that prices are sticky in the local currency and that changes in the exchange rate lead to deviations in the law of one price.

Not only are failures of the law of one price significant but, as recent evidence suggests, they also play a dominant role in explaining the behavior of real exchange rates. Engel (1999) measures the proportion of U.S. real exchange rate movements that can be accounted for by movements in the relative prices of nontraded goods. Engel decomposes the CPI real exchange rate into two components: a weighted difference of the relative price of nontraded-to traded-goods prices in each country, and the relative price of traded goods between the countries. If tradables, as a category, closely followed the law of one price, then all variability in the real exchange rate would be explained by movements in the first component. However, Engel finds that movements in the relative price of nontraded goods appear to account for almost none of the movement in U.S. real exchange rates, even at long time horizons. Instead, nearly all the variability can be attributed to movements in the relative price of tradables. This finding strongly suggests that consumer markets for tradable goods are highly segmented internationally and that movements in the international relative price of consumer tradables are very persistent.[11] Moreover, given the high volatility of nominal exchange rates, these findings indicate that consumer prices of most goods (either imported or domestically produced) seem to be sticky in domestic currency terms.

An alternative approach to studying the relationship between exchange rates and goods prices is examining how firms in a industry (or country) pass through changes in exchange rates to export prices.[12] Knetter (1989, 1993)

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[10] See, for example, the empirical studies in Isard (1977), Giovannini (1988), or Engel (1993).

[11] One should note, however, that at the consumer level, even highly tradable goods embody a large nontradable component.

[12] Exchange rate pass-through is the percentage change in local currency import prices resulting from a 1 percent change in the exchange rate between the exporting and importing countries.

measures the degree of price discrimination across export destinations that is associated with exchange rate changes for U.S., U.K., German, and Japanese industry-level data. He finds that the amount of exchange rate pass-through differs considerably depending on the country and industry. Goldberg and Knetter (1997) provide an extensive survey of the literature and find that local currency prices of foreign products do not respond fully to exchange rate changes. While the response varies by industry, on average exchange rate pass-through to U.S. import prices is only about 50 percent after one year, mainly reflecting changes in destination-specific markups on exports.

In brief, there is strong evidence that international markets for tradable goods remain highly segmented and that deviations from PPP are largely accounted for by movements in the relative price of tradable goods across countries. At the consumer level, exchange rate pass-through to import prices is virtually zero (suggesting that consumer prices are sticky in domestic currency). At the producer level, however, exchange rate pass-through is generally positive, but substantially below one.

Transaction Costs and the Adjustment of PPP and Law of One Price Deviations

Some recent empirical tests of long-run PPP and the law of one price have abandoned the conventional framework, which assumes a linear autoregressive process for the price differential. Instead, these studies have started to look into nonlinear models of price adjustment, where the speed at which price differentials die out depends on the size of the deviation itself.

This alternative framework for the empirical analysis of price differentials is motivated by the observation that commodity trade is not costless. Persistent deviations from the law of one price are implied as an equilibrium feature of models with transaction costs, for deviations will be left uncorrected as long as they are sufficiently small relative to the shipping cost.[13]

The simplest econometric model that implements the notion of a nonlinear adjustment for price differentials assumes that the process is well described by a random walk for small deviations (that is, when deviations are within a "band of inaction") and an autoregressive process for large deviations (that is, when deviations are outside the band).[14] Taylor (2001) shows that the

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[13] See Dumas (1992) and Ohanian and Stockman (1997) for equilibrium models of exchange rate determination in the presence of transaction costs. Obstfeld and Rogoff (2000a) argue for the importance of transaction costs in explaining several puzzles in international macroeconomics.

[14] Specifically, the price differential q_t follows the process

$$q_t = \begin{cases} c + \rho\left(q_{t-1} - c\right) + \varepsilon_t & \text{if } q_{t-1} > c, \\ q_{t-1} + \varepsilon_t & \text{if } c \geq q_{t-1} \geq -c, \\ -c + \rho\left(q_{t-1} + c\right) + \varepsilon_t & \text{if } -c > q_{t-1}, \end{cases}$$

improper use of linear models when the true model is nonlinear may produce a large bias towards finding a low speed of convergence.[15] Intuitively, a linear model will fail to support convergence to PPP if the true model is nonlinear and the process spends most of the time in the random-walk band. Using both monthly data from the 1920s and annual data spanning two centuries, Michael, Nobay, and Peel (1997) reject the linear adjustment model in favor of a nonlinear model and provide strong evidence of mean-reverting behavior for PPP deviations for every exchange rate considered.[16]

2. INTERNATIONAL PRICING IN NEW OPEN-ECONOMY MACROECONOMIC MODELS

The common starting point for most of the recent research in open-economy models with price rigidities is the model developed in Obstfeld and Rogoff (1995).[17] This model explores the international monetary transmission mechanism in a general equilibrium setup characterized by nominal price rigidities, imperfect competition, and incomplete asset markets.

Obstfeld and Rogoff's model does not generate deviations from the CPI-based purchasing power parity. This feature reflects the fact that preferences are identical across countries and that all goods are freely tradable, with prices set in the seller's currency. In this model, there is complete pass-through of exchange rate changes to import prices, implying that the law of one price always holds for all goods and that the real exchange rate is constant.

Motivated by the empirical evidence on the sources of real exchange rate fluctuations, several recent papers have extended Obstfeld and Rogoff's framework in order to allow for pricing-to-market[18] and deviations from the law of one price. This class of models assumes that home and foreign markets are segmented, which allows imperfectly competitive firms to price discriminate between home and foreign consumers.[19] Consumers' inability to arbitrage price differentials between countries is exogenous, possibly reflecting arbitrarily high transportation costs at the consumer level. In addition to market

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where $\varepsilon_t \sim N\left(0, \sigma^2\right)$. This process is parametrized by ρ, the autoregressive coefficient for deviations from the band's edge, and c, which determines the amplitude of the band of inaction.

[15] Taylor (2001) also addresses the problem of temporal aggregation and shows that the use of relatively low-frequency data may also produce large biases in these estimates.

[16] See also Obstfeld and Taylor (1997) and Taylor, Peel, and Sarno (2001).

[17] This work extends the model in Svensson and van Wijenbergen (1989), an endowment two-country dynamic general equilibrium model, where monopolistic competitive firms set prices one period in advance and asset markets are complete.

[18] Strictly speaking, the term *pricing-to-market* refers to the ability of firms to engage in third-degree price discriminations across different export destinations. In its current use, however, the term has come to include the additional assumption that firms set their prices in advance in the local currency of the buyer.

[19] See Betts and Devereux (1996) for the initial contribution.

segmentation, this class of models also assumes that prices are sticky in each country's local currency. That is, firms set prices in advance in the buyer's currency, as opposed to the standard assumption that prices are set in the seller's currency.[20]

I next outline a basic model in which firms set prices in advance in the local currency of the buyer (or pricing-to-market). The model is then used to explore the main implications of pricing-to-market.

A Simple Model of Local-Currency Pricing

There are two countries, home and foreign. Households in each country consume a continuum of differentiated goods, which are indexed by i, $i \in [0, 1]$. A fraction n of these goods is produced by firms located in the home country, and the remaining fraction $1 - n$ is produced by firms located in the foreign country.[21]

Home and foreign households have identical preferences. In the home country, these preferences are defined by

$$U = \sum_{t=0}^{\infty} \beta^t u \left(c_t, \frac{M_t}{P_t}, 1 - l_t \right).$$

The term c_t represents the agent's total consumption. It is an index given by

$$c_t = \left[\int_0^1 c_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}}, \tag{1}$$

which aggregates the consumption of all differentiated goods, $c_t(i)$. The parameter θ is the elasticity of substitution between any two differentiated goods, and for values of θ greater than 1, different goods are imperfect substitutes in consumption. Besides consumption, the consumer's momentary utility also depends on leisure, $1 - l_t$, and real money balances held during the period, $\frac{M_t}{P_t}$, where M_t are nominal balances and P_t is the home country consumption price index.

Let $p_t(i)$ represent the home currency price of good i. Given these prices, P_t represents the minimum expenditure necessary to buy one unit of composite good c. The price index corresponding to c is given by

$$P_t = \left[\int_0^1 p_t(i)^{1-\theta} di \right]^{\frac{1}{1-\theta}}. \tag{2}$$

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[20] In these models, the firm's choice of invoice currency is exogenous. See Devereux and Engel (2001) for a recent contribution to the literature in which exporting firms can also choose the currency in which they set export prices. They find that exporters will generally wish to set prices in the currency of the country that has the most stable monetary policy.

[21] The fractions n and $1 - n$ also represent the sizes of the home and foreign countries, respectively.

Given the aggregate consumption index (1), the household's optimal allocation of consumption across each of the differentiated goods yields the demand functions

$$c_t(i) = \left(\frac{p_t(i)}{P_t} \right)^{-\theta} c_t, \, i \in [0, 1]. \tag{3}$$

Note that home demand functions for foreign goods $c_t(i)$, $i \in [n, 1]$, do not depend on the nominal exchange rate. As we shall see, this follows from the fact that the home price of foreign goods is denominated in the home currency.

As outlined above, home and foreign markets are segmented, effectively allowing firms to price discriminate across the two markets. Therefore, home firm i, $i \in [0, n]$, will choose separately the price for its good in the home country, $p_t(i)$, and in the foreign country, $p_t^*(i)$, in order to maximize its total profits. By assumption, these prices are denominated in the buyer's currency. That is, $p_t(i)$ is denominated in home currency and $p_t^*(i)$ is denominated in foreign currency.

Home firm i operates the production function $y_t = l_t(i)$, where $l_t(i)$ represents hours worked, and period t profits are given by $\pi_t(i) = p_t(i) c_t(i) + e_t p_t^*(i) c_t^*(i) - w_t(c_t(i) + c_t^*(i))$. The term w_t is the real wage rate and the nominal exchange rate, e_t, converts the revenues from sales in the foreign country into home currency. Profit maximization is made subject to the firm's production function and home and foreign demand functions for its good (equation (3) and the analogous expression for the foreign consumer).

When nominal prices are flexible, home firm i sets its prices as

$$p_t(i) = e_t p_t^*(i) = \frac{\theta}{\theta - 1} w_t,$$

i.e., the optimal pricing function rule for each firm is to set its price in each market as a constant markup over marginal cost.[22] Therefore, the law of one price holds for each good, even though firms have the ability to price discriminate across markets. The model with flexible prices does not generate deviations from PPP.[23]

Next suppose that firms set prices in advance at a level that achieves the optimal markup in the absence of shocks. Firms cannot adjust prices within the period in response to shocks, accommodating ex-post demand at the preset prices. Prices adjust fully after one period. As before, firms are assumed to set prices in the local currency of sale. Therefore, in this case, unanticipated changes in the exchange rate lead to deviations in the law of one price. In this model, deviations from PPP result only from deviations from the law of

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[22] In this monopolistic competition framework, markups are constant, precluding the analysis of possible effects of exchange rates on markups.

See Bergin and Feenstra (1998) for a pricing-to-market model with translog preferences that departs from the monopolistic competition framework.

[23] This is a result of assuming that the elasticities of demand are identical in both markets.

one price, i.e., from movements in the relative price of similar goods across countries.

The Transmission of Monetary Shocks

When prices are preset in the buyer's currency, an unexpected depreciation of domestic currency has no expenditure-switching effect in the short run. In response to the exchange rate change firms are assumed to keep foreign currency export prices fixed, allowing their foreign markups to adjust. Since consumer demand functions do not depend on the nominal exchange rate and exchange rate pass-through to consumer prices is zero on impact, changes in this variable are dissociated, on impact, from allocation decisions.

In response to an unexpected positive shock to the home money supply, the nominal exchange rate immediately depreciates. Since prices only respond after one period and are denominated in the buyer's currency, the adjustment in the nominal exchange rate translates into a real depreciation and does not affect the relative price of home and foreign goods in either country. Thus, the increase in total consumption in the home country associated with the positive money shock is brought about by an increase in consumption of both domestic and foreign goods in the same proportion, as equation (3) shows. If, instead, prices were set in the seller's currency, the increase in the nominal exchange rate would lead to an immediate increase in the home currency price of foreign goods ($e_t p_t(f)$, where $p_t(f)$ is now denominated in foreign currency), while the price of home goods in the home country, $p_t(h)$, would remain unchanged. Similarly, nominal depreciation would reduce the foreign currency price of home goods ($\frac{p_t^*(h)}{e_t}$, with $p_t^*(h)$ denominated in home currency), while leaving the price of foreign goods in the foreign country, $p_t^*(f)$, unchanged. Thus, in this case, the positive money shock would decrease the relative price of home to foreign goods on impact in both countries[24] and both agents would substitute consumption towards home goods and away from foreign goods. Thus, having prices set in the buyer's currency eliminates, on impact, the expenditure switching effect associated with unexpected changes in the nominal exchange rate; the absence of this effect in turn influences the international transmission of monetary disturbances.

Without pricing-to-market, monetary disturbances tend to generate high positive comovements of consumption across countries and large negative comovements of output. In response to a positive money shock in the home country, the real exchange rate (i.e., the relative price of consumption across

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[24] With seller's currency, this relative price in the home country would be $\frac{p_t(h)}{e_t p_t(f)}$, where $p_t(f)$ is now preset in units of foreign currency. An unexpected rise in e_t lowers this relative price.

countries) remains constant, leading to the large positive comovement of consumption across countries. Consumption increases in both countries, reflecting the increase in real money balances in the home country and the decline in the consumer price index in the foreign country. At the same time, foreign goods become more expensive relative to home goods and both agents substitute consumption towards home goods and away from foreign goods. Therefore, in response to this expenditure-switching effect, production shifts away from the foreign country to the home country, implying a negative comovement of output across countries.

With pricing-to-market, a positive money shock in the home country is associated with a real exchange rate depreciation, which leads the comovement of consumption across countries to fall. In this case, however, the relative price of home to foreign goods is left unchanged and the elimination of the expenditure switching effect increases the comovement of output across countries.

**Implications of Local-Currency Pricing for
Two-Country Models**

Several recent papers have explored the implications of incomplete short-run exchange rate pass-through for a series of wide-ranging questions in international economics. Since the nature of international pricing has a crucial effect on the international transmission of monetary disturbances, this assumption substantially affects the business-cycle properties of open-economy models, the welfare properties of alternative exchange rate regimes, and the characterization of optimal monetary and exchange rate policies. I now highlight some of these issues.

Chari, Kehoe, and McGrattan (2000) calibrate a stochastic pricing-to-market model and investigate whether the interaction of staggered prices with money shocks can account for the observed behavior of real exchange rates.[25] They show that their model is successful in generating real exchange rates that are as volatile as in data, but not as persistent. Since in a monopolistic competition framework unexpected money shocks do not generate movements in the real exchange rate beyond the periods of (exogenously-imposed) nominal stickiness, this model is not able to generate sufficiently persistent real exchange rates.[26]

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[25] See Kollmann (1997) for a calibrated small open economy in which both wages and prices are sticky.

[26] See Bergin and Feenstra (2001) for an exploration of the volatility and persistence properties of real exchange rates in a model with translog preferences and intermediate inputs that generates endogenous persistence. In a closed economy setup, Dotsey and King (2001) build a model with structural features that substantially reduce the elasticity of marginal cost with respect to output, generating greater endogenous persistence. The implication of this model's features for the behavior of real exchange rates in a two-country model is still an open question.

The business-cycle properties of different exchange rate regimes are explored in Duarte (2001) in a calibrated pricing-to-market model. Baxter and Stockman (1989) and Flood and Rose (1995) show that, following a change from pegged to floating exchange rate systems, countries with moderate inflations experience a systematic and sharp increase in the variability of the real exchange rate, while the behavior of other macroeconomic variables remains largely unaffected by the change in regime. This puzzling evidence can be accounted for in a model with prices set one period in advance in the local currency of the buyer. By eliminating the expenditure-switching effect of exchange rates in the short run, this model predicts a sharp increase in the volatility of the real exchange rate following a change from fixed to flexible exchange rates, without generating a similar pattern for the volatilities of output, consumption, or trade flows.

Devereux and Engel (1998) compare the welfare properties of fixed and flexible exchange rate systems in an explicitly stochastic setting. Under uncertainty, firms incorporate a risk premium in their pricing decision, which affects the equilibrium prices that are chosen. This effect on equilibrium prices in turn has an impact on expected output and consumption levels and ex-ante welfare levels. Devereux and Engel show that the exchange rate regime influences not only the variance of consumption and output, but also their average values, and that the optimal exchange rate regime depends crucially on the nature of pricing. They find that under producer-currency pricing there is a trade-off between floating and fixed exchange rates, while floating exchange rates always dominate fixed exchange rates under consumer-currency pricing.

The nature of currency pricing also has substantial implications for the welfare effects of monetary policy and international policy coordination. Since consumer import prices do not respond in the short run to changes in the exchange rate, pricing-to-market models predict that unexpected currency depreciations are associated with an *improvement* of the country's terms of trade, rather than with the deterioration that occurs with producer-currency pricing. For example, if the dollar depreciates and consumer prices are sticky (in the local currency), then the dollar price paid in the United States for imported goods remains the same, while the price of American exported goods rises when translated into dollars. Betts and Devereux (2000) show that this effect of domestic monetary expansions on the terms of trade raises domestic welfare at the expense of foreign welfare. That is, expansionary monetary policy is a "beggar-thy-neighbor" instrument. This result contrasts sharply with the prediction from a model with PPP, where a surprise monetary expansion in one country raises welfare in both countries (Obstfeld and Rogoff 1995).

Obstfeld and Rogoff (2000b) argue that the positive relation between exchange rate depreciations and terms of trade implied by pricing-to-market models is at odds with the empirical evidence. They present some evidence supporting the conventional idea that currency depreciations cause the terms

of trade to deteriorate. The role of the degree of exchange rate pass-through in the allocative effect of exchange rate changes and the importance of this mechanism in the properties of open-economy models show that it is crucial to explore the implications of new open-economy models with more realistic pricing assumptions. In particular, it is important to study the implications of models that can distinguish the apparent zero exchange rate pass-through at the consumer level from the clearly positive (but smaller than one) exchange rate pass-through at the producer level. In a recent contribution to the literature, Corsetti and Dedola (2001) introduce labor intensive distribution services in an otherwise standard two-country model with preset wages. They show that the law of one price fails to hold at both producer and consumer levels and that monetary shocks may result in expenditure switching effects.

3.   CONCLUDING REMARKS

This article focuses on the implications of alternative international price-setting regimes in open-economy models that incorporate nominal price rigidities and monopolistic competition. Most of the recent research in this field has progressed under the assumption of either producer-currency pricing or consumer-currency pricing. Since the nature of price setting determines the effect of exchange rate changes on the relative price of imported to domestic goods in the short run, the price-setting assumption determines the role of exchange rates in shifting consumer allocation decisions across countries. Therefore, the international monetary transmission mechanism differs markedly under these two alternatives, yielding very different predictions for many substantial issues in international economics.

Assuming that prices are set in advance in the consumer's currency allows for short-run deviations in the law of one price for tradable goods, which occur in response to unexpected changes in the exchange rate. These deviations in turn generate movements in the real exchange rate, as is suggested by recent empirical evidence. Pricing-to-market models have been able to replicate a number of key international business-cycle properties, both for floating exchange rate periods and across alternative regimes.

In pricing-to-market models, exchange rate pass-through to consumer import prices is zero in the short run. This feature of the model implies that exchange rate depreciations and the terms of trade are positively correlated, a relation that is not supported by the data.

While the data suggests that exchange rate pass-through at the consumer level is indeed close to zero, it is clearly positive (but incomplete) at the producer level. Given the crucial role played by the international price-setting regime in the international transmission mechanism of monetary disturbances, it is clearly important to explore the implications of distinct exchange rate pass-throughs at the consumer and producer levels.

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