

The Exchange Rate: What's in It for Prices?*

BY GEORGE ALESSANDRIA AND JARCY ZEE

Large movements in the exchange rate are quite common, and they substantially alter one's purchasing power when traveling abroad. Yet these exchange rate movements tend to have a smaller impact on the price of foreign goods that are imported. Following an appreciation of the euro against the dollar, European firms selling products to American firms for import do not raise their prices by nearly as much as the prices they charge consumers in the European market. Similarly, American firms sell their products at higher prices in Europe than at home. This incomplete, or partial, pass-through of exchange rate movements to domestic import prices is important for inflation, American purchasing power, and the pattern of trade between countries. In this article, George Alessandria and Jarcy Zee discuss some of the reasons why changes in the exchange rate may not be fully passed through to import prices.

In the summer of 2008, traveling to Europe was quite expensive for Americans, while traveling to the U.S. was a bargain for Europeans. For



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instance, on average, a Big Mac¹ was almost 50 percent more expensive in Europe than in the U.S. (\$5.31 in Europe and only \$3.57 in the U.S.). Just five years earlier, the gap was much smaller: Big Macs in Europe cost only about 15 percent more than Big

¹ Big Mac™ is a registered trademark of the McDonald's Corporation.

*The views expressed here are those of the authors and do not necessarily represent the views of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

Macs in the U.S. (\$3.05 in Europe and \$2.65 in the U.S.).² A key component of the 35 percent increase in the price of European Big Macs relative to U.S. Big Macs was a nearly 50 percent depreciation of the U.S. dollar relative to the euro: from \$1.06 per euro in January 2003 to \$1.58 per euro in July 2008. As the dollar depreciated, McDonald's raised both the Big Mac's dollar price in the U.S. and the euro price in Europe, but the price increase in the U.S. was not large enough to offset the effect of a weaker dollar, making European Big Macs relatively more expensive.

The increase in the relative price of European Big Macs was typical for a broad range of goods. Over this same period, the broad basket of goods making up the European consumer price index³ (CPI) became 45 percent more expensive relative to the broad

² Based on Big Mac prices as of July 24, 2008, and January 16, 2003. The Big Mac index is published periodically by *The Economist* and is a useful way of comparing the price of goods in different countries. For more information about the Big Mac index, go to <http://www.economist.com/markets/bigmac/>.

³ The consumer price index measures the price of a basket of goods that the typical consumer in a country purchases. The CPI is one of the main indicators measuring inflation.

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basket of goods making up the U.S. CPI. Just as with the Big Mac, the main source of the increase in the price of European goods in Europe relative to U.S. goods in the U.S. was the 50 percent depreciation of the U.S. dollar against the euro.⁴ Only a small part of this exchange rate movement was offset by U.S. prices rising slightly faster than European prices in euros (18 percent rise in the U.S. vs. 13 percent rise in Europe).

These movements in the exchange rate have made buying all goods in the U.S. relatively inexpensive compared with buying goods in Europe, even if these goods were produced in Europe.⁵ For instance, while the sticker price of an Audi A4 sold in the U.S. but produced in Germany rose 13 percent in dollars from 2003 to 2007, its sticker price in Germany when converted to dollars rose 28.5 percent as the dollar depreciated.⁶ Across a broad range of imported goods, we find similar price changes in that European firms selling products to American firms for import have not raised their prices by nearly as much as the price they charge Europeans to buy their products in Europe. Similarly, American firms

are selling their products to Europe for more than they sell their products at home. These pricing policies imply that U.S. consumers purchasing imports have been partially insulated from the effect of a weaker dollar.

The incomplete, or partial, pass-through of exchange rate movements to domestic import prices is important for inflation, American purchasing power, and the pattern of trade between countries. In this article, we present some evidence on the pass-through of the changes in the exchange rate to import prices in the U.S. and abroad, and we discuss some reasons why changes in the exchange rate may not fully pass through to import prices.

BEHAVIOR OF EXCHANGE RATES AND CONCEPT OF PASS-THROUGH

The nominal exchange rate, which measures the rate at which one

country's currency can be exchanged for another country's currency, tends to experience large and sustained changes. As seen in Figure 1, the U.S. nominal exchange rate relative to the currency of its trading partners (the dashed line) fell substantially from 1996 to 2002, so that it took 29 percent fewer U.S. dollars to buy one unit of foreign currency in 2002 than in 1996. This period of U.S. dollar appreciation was followed by a period, from 2002 to 2008, when the nominal exchange rate increased 29 percent, indicating a depreciation of the U.S. dollar.

These changes in the nominal exchange rate are not offset by movements in the local prices or production costs of goods, so that there are also large and sustained changes in the relative cost of producing goods or buying goods in different countries. The real exchange rate, which measures the cost of goods sold in the

⁴ The relative change in price, Δq , is calculated by $\Delta q = \Delta e + \Delta p - \Delta p^*$, where Δe is the change in the nominal exchange rate, Δp is the change in the U.S. price level, and Δp^* is the change in the European price level.

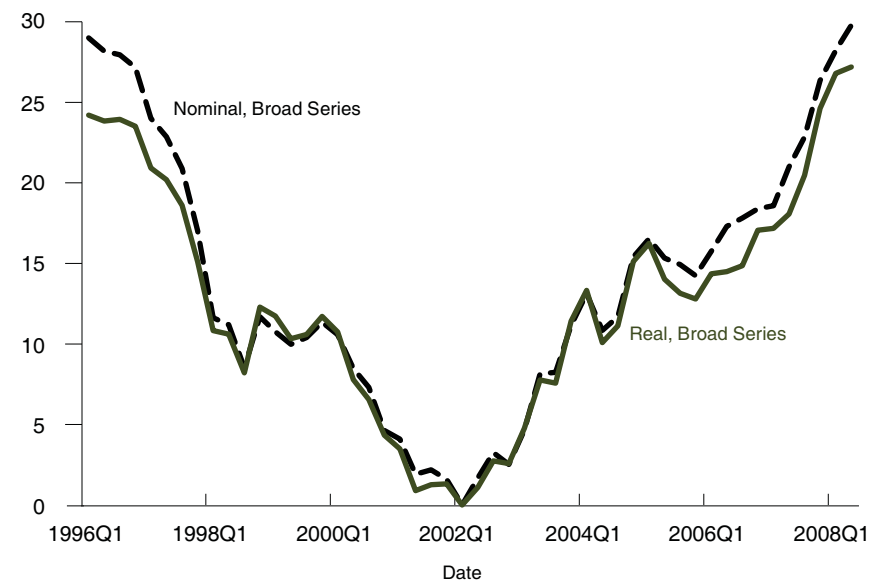
⁵ Since the first quarter of 2003, nominal European manufacturing costs have risen 14.5 percent in euros, while U.S. manufacturing costs have risen only 12.1 percent, measured in dollars.

⁶ These price changes are based on sticker prices in the U.S. from annual issues of Ward Automotive's *Car Specifications and Prices* and pre-tax sticker prices in Germany from the European Commission's biannual car price reports in May 2003 and May 2007. In 2003, the U.S. model was an Audi A4 1.8T FrontTrak (1.8L, 170 hp), and the German model was an Audi A4 1.9 TDI (1.9L, 130 hp). In 2007, the model priced in each country was an Audi A4 2.0 TDI. Exchange rate conversions were \$1.13/euro in 2003 and \$1.37/euro in 2007.

FIGURE 1

U.S. Nominal and Real Exchange Rates

Percentage Change (measured as log difference) from 2002Q1



U.S. relative to the rest of the world, is calculated as a ratio of foreign and domestic consumer prices measured in a common currency. Because most goods consumed are domestically produced, the real exchange rate provides a good proxy for how the relative cost of producing goods in different countries changes over time. Figure 1 demonstrates that the real exchange rate (solid line) and nominal exchange rate (dashed line) tend to move together, indicating that relative production costs are highly correlated with the nominal exchange rate.

These fluctuations in the cost of producing goods in the U.S. relative to overseas markets also affect the cost of producing the goods that the U.S. imports (and exports). In response to the movements in relative costs, foreign firms alter the price they charge for their goods in the U.S. and at home. Figure 2 shows both how the relative cost of American goods fluctuates (the real exchange rate indicated by the solid green line) and how the price of imported goods relative to the price of goods produced in the U.S. changes. The two lines have a similar pattern. As the cost of producing goods overseas fell relative to the U.S. from 1996 to 2002, so did the price of goods imported to the U.S. Similarly, as the cost of producing goods overseas rose from 2002 to the present, so did the price of imported goods. The magnitudes are quite different, though. From 1996 to 2002, relative to the cost of producing and selling U.S. goods, the cost of foreign goods fell 24 percent, while the price at which Americans could import these goods fell about 13 percent. Similarly, since 2002, producing goods overseas has become about 27 percent more expensive than producing in the U.S., yet the price at which these goods are imported into the U.S. has risen only about 15 percent. Thus, import

price movements tend to be smaller than movements in relative costs or exchange rates.

The extent of pass-through can be measured as the ratio of the change in the import price to the change in relative production costs. A pass-through value of 100 percent denotes complete pass-through and indicates that a 10 percent change in foreign cost results in a 10 percent change in the import price. Pass-through less than 100 percent, denoted as incomplete or partial pass-through, implies that prices are less responsive to movements in relative production costs. To measure pass-through, we could just use the nominal exchange rate as a measure of the relative change in costs. However, because the exchange rate movement may be associated with changes in the costs of producing the good, the approach we take will be conditioned on changes in costs. To control for these changes in

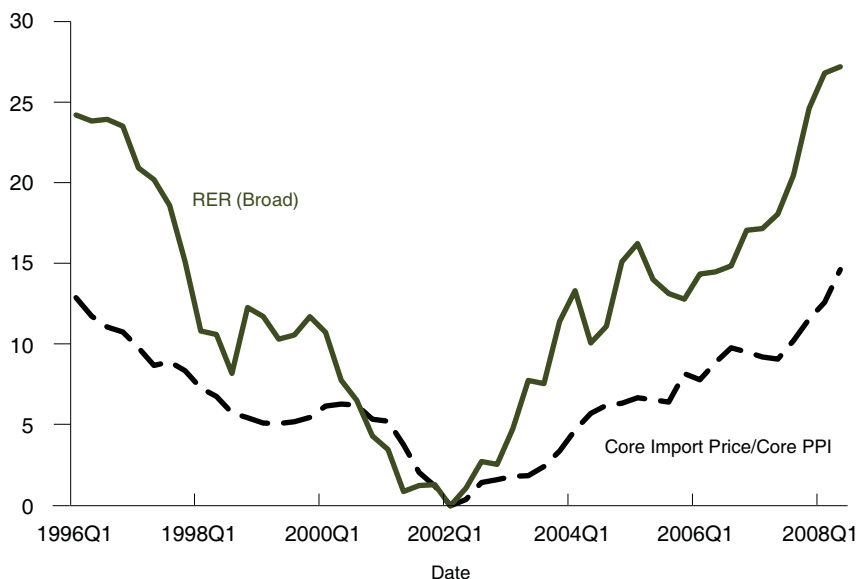
costs, for import prices, it is common to use a measure of costs or prices in the source market. For our baseline, we take the change in price in the source country market measured in nominal terms using the destination market's currency as a measure of the change in costs and then estimate pass-through using the change in price in the destination market.

For example, suppose the ABC car company charges \$10 for a car in its home market of Europe when converted to U.S. dollars and \$10 for the same car in the U.S. If the company raises its price to \$20 in Europe and \$17 in the U.S., pass-through is 70 percent. However, the price change in Europe relative to the U.S. may result from either a change in the euro to dollar nominal exchange rate or from the cost of producing the good. Suppose initially that \$1 can be exchanged for 1 euro and the car sells for 10 euros in Europe and \$10

FIGURE 2

Import Prices Relative to Producer Prices

Percentage Change (measured as log difference) from 2002Q1



in the U.S. In the next year, suppose the U.S. dollar depreciates, so now \$2 are needed to buy 1 euro. If ABC keeps its car price in Europe at 10 euros, or \$20 when converted to U.S. currency at the new exchange rate, but raises its price in the U.S. to \$17, we find pass-through to be 70 percent.⁷ Alternatively, suppose the nominal exchange rate does not change but that the price of steel, an important input for producing cars, increases. If ABC decides to double its price in Europe to 20 euros, or \$20 at a constant \$1 per euro exchange rate, and raise its price to only \$17 in the U.S., we will also find pass-through to be 70 percent.⁸

EVIDENCE OF INCOMPLETE PASS-THROUGH

Many studies measure pass-through in different countries, industries, and time periods. These studies also distinguish between pass-through to import prices and pass-through to the consumer price index. The focus here is on pass-through to import prices in the long run. *Empirical Estimates of Exchange Rate Pass-Through* explains the empirical framework of some of these studies. Pinelopi Goldberg and Michael Knetter survey these studies and find that pass-through to import prices is about one-half. Thus, if foreign costs rise 10 percent, the import price of foreign goods is expected to rise 5 percent. Pass-through is nearly the

$${}^7 ERPT = \frac{\Delta p}{\Delta e + \Delta p^*} = \frac{0.7}{1 + 0} = 0.7,$$

where Δp is the percent change in price, Δe is the percent change in the nominal exchange rate, and Δp^* is the percent change in the foreign price.

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Empirical Estimates of Exchange Rate Pass-Through

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ecent research has focused on understanding how pass-through has changed over time and how it differs across countries. A study by Mario Marazzi and co-authors uses disaggregated data to document a decline in exchange rate pass-through since the 1980s and to attribute it to the decrease in industry-specific changes. José Campa and Linda Goldberg study trade between the U.S. and a broader sample of countries to observe pass-through across time.

The two studies use a similar empirical framework, running a regression of changes in import prices on changes in the exchange rate and foreign costs using quarterly data:

$$\Delta p_t^j = \beta_j + \sum_{i=0}^4 \alpha_i^j \Delta e_{t+i}^j + \sum_{i=0}^4 b_i^j \Delta w_{t+i}^j + \sum_{i=0}^4 c_i^j \Delta p_{t+i}^{com} + \sum_{i=0}^4 d_i^j \Delta gdp_{t+i}^j + v_{it}^j$$

where for country j , p_t^j is the import price, e_t^j is the exchange rate, w_t^j is foreign cost, gdp_t^j is real GDP and p_t^{com} is a measure of commodity prices. The regressions in the two papers differ slightly. Campa and Goldberg run their regression using quarterly data from the first quarter of 1976 to the first quarter of 2004 for 16 countries and drop the term controlling for commodity prices. Marazzi and co-authors focus on just the U.S. from the fourth quarter of 1972 to the fourth quarter of 2004, exclude the term of real GDP, and constrain the term on foreign costs measured using foreign price levels to be the same as that on the exchange rate.

Short-run pass-through is represented by the coefficient α_0^j and long-run pass-through is represented by the sum of coefficients $\sum_{i=0}^4 \alpha_i^j$. Campa and Goldberg find that long-run pass-through of exchange rates into manufacturing import prices is about 44 percent for the U.S. using this regression. Their micro estimates from the broad range of countries show an average exchange rate pass-through into manufacturing import prices of about 60 percent.

Marazzi and co-authors find that pass-through to import prices in the 1980s was roughly 50 percent, but it has declined to about 20 percent in the mid-1990s. Campa and Goldberg, however, find less evidence of the decline in a broader sample of countries.

same following either an increase or a decrease in foreign costs.⁹

Pass-through also tends to vary by industry: It's relatively high for raw materials and energy and relatively low for

⁹ In a study of exchange rate pass-through to U.S. import prices, Giovanni Olivei finds that pass-through does not depend on the direction of the exchange rate movement in 32 out of 34 industries.

manufactured goods. José Campa and Linda Goldberg estimate pass-through from a broad sample of countries in the energy industry to be about 77 percent, on average. Giovanni Olivei estimates pass-through for nonenergy industries and finds pass-through of about 39 percent for the automobile industry, in the long run.

We next turn to the recent evidence of pass-through to import

prices for manufactured goods between the U.S. and two of its major trading partners, Canada and the European Union. Together, Europe and Canada account for about 30 percent of U.S. international trade over the period 2000 to 2007. We focus on these countries not only because they are major trading partners of the U.S. but also because we have fairly accurate measures of both their production costs and U.S. import prices. There have also been some fairly large and sustained exchange rate movements that allow us to measure pass-through over long intervals.¹⁰

Pass-through on European goods to prices in the U.S. has been approximately 25 percent. Figure 3 presents the relative cost of manufactured goods produced in Europe to manufactured goods produced in the U.S. (solid line). As before, we split the period evenly between a large appreciation of the dollar from 1996 through the first quarter of 2002 and a large depreciation since then. In the first half of the sample, European goods became 38 percent less expensive to produce, yet the import price (the dashed line) fell only by about 10 percent, indicating that pass-through was just under 25 percent. In the second half of the sample, producing European goods became just over 60 percent more expensive, yet import prices rose only about 14.5 percent. Again pass-through was only about 25 percent.

At about 50 percent, pass-through on Canadian goods has been somewhat

¹⁰ While we focus on pass-through of relative cost movements that occurred along with changes in nominal exchange rates, it is also possible to measure pass-through of relative costs when the exchange rate does not change, such as when a country follows a fixed exchange rate regime.

higher than for European goods. Figure 4 presents the cost of manufactured goods produced in Canada relative to the cost of goods manufactured in the U.S., again divided into a period of dollar appreciation followed by a period of depreciation. In the first half of the sample, Canadian goods became about 13 percent cheaper to produce than American goods, and this translated into a drop in the price of Canadian imports of just under 7 percent, for pass-through of about 52 percent. In the latter half of the sample, the situation reversed, with relative costs rising 29 percent and import prices rising about 15.5 percent. Again, pass-through was just over 50 percent.

WHY IS PASS-THROUGH INCOMPLETE?

Fundamentally, incomplete pass-through suggests that firms are sometimes charging different prices for

the same good in different countries¹¹ and that, over time, they are changing prices in each market by different amounts. We now discuss some of the common reasons why firms may elect to change their prices by different amounts in different countries following a change in their costs.

One common reason for incomplete pass-through, suggested by Rudiger Dornbusch, is that firms face different competitors in each market, and therefore, exchange rate movements affect the competitive environment differently across countries. For instance, most cars available in the U.S. are produced in the U.S., while most cars available in Europe are produced in Europe.

¹¹ The *Business Review* article by George Alessandria and Joseph Kaboski presents evidence that some of the long-run differences in prices across countries are related to differences in income.

FIGURE 3

Europe's Real Exchange Rate and Import Prices

Percentage Change (measured as log difference) from 2002Q1

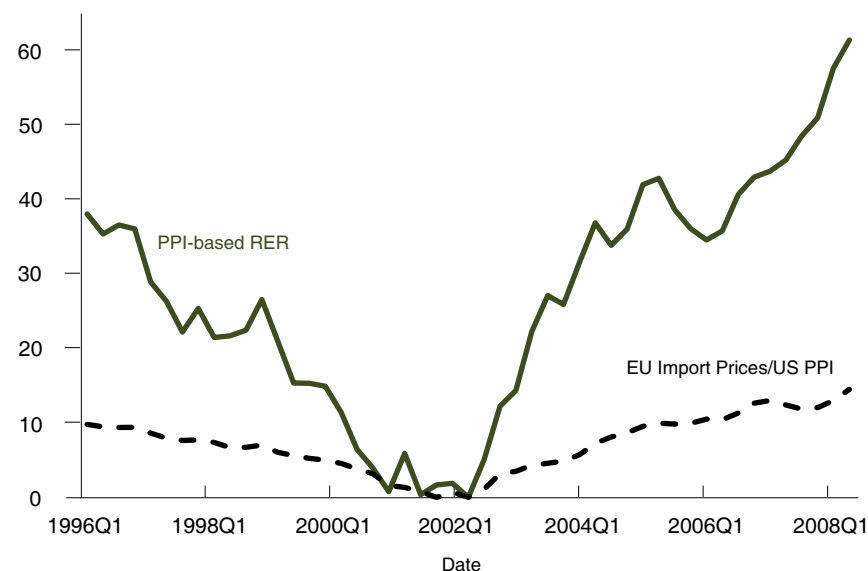
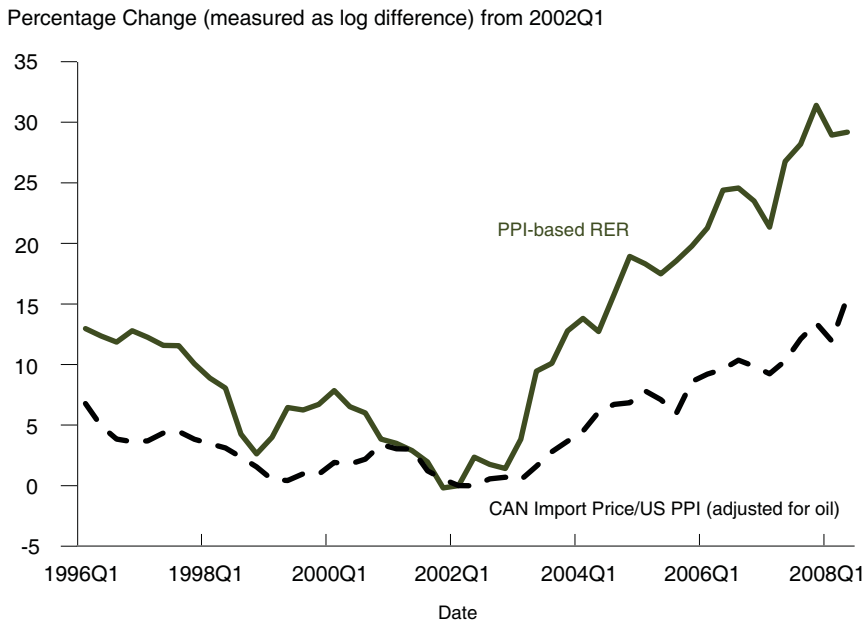


FIGURE 4**Canada's Real Exchange Rate and Import Prices**

But, of course, you can find European cars in the U.S. and U.S. cars in Europe. When the euro appreciates, or becomes more valuable compared to the dollar, European carmakers will face higher relative costs. In the U.S., European carmakers may find it difficult to raise their prices, since there are many relatively low-cost U.S. cars available. In Europe, however, there are fewer relatively low-cost U.S. cars available, so European carmakers can raise their prices by more, or at least they do not have to lower prices to avoid losing customers.

Firms exporting their goods to the U.S. may also decide not to raise their prices following a depreciation of the dollar because doing so would have a negative impact on its future profits. For instance, an automaker that sells a car today also expects to sell repair services for that car in the

future and increases the likelihood that the same customer will buy another car in the future. Thus, if that automaker raises its prices a lot today and sells fewer cars, it will have fewer customers (and sales and profits) in the future. A study by George Alessandria shows that firms carefully consider the effects of their price changes on both today's profits and future profits. It turns out that maximizing the sum of current and future profits may imply a relatively smaller price adjustment today in order to prevent losing customers and future sales and service.

Local inputs to production of foreign goods can also cause import prices to move by less than the exchange rate. In a 2002 article, José Campa and Linda Goldberg find that increases in the amount of imported inputs that originate from the home market, used in goods that are eventu-

ally re-exported to the home country, are associated with lower pass-through into import prices. For instance, the cost of an Airbus airplane imported to the U.S. from Europe would be expected to rise with an appreciation of the euro. However, if the airplane's engines are produced by GE in the U.S. with a relatively constant cost in dollars, the cost to Airbus of producing the airplane will not have risen by the same amount as the exchange rate. Thus, Airbus may raise its price by less than the exchange rate has appreciated. In our estimates of pass-through, these effects of inputs on prices are captured by the foreign cost, so it only shows up in an estimate of pass-through that uses the nominal exchange rate to measure costs.

Incomplete pass-through to import prices may also arise if local inputs are bundled to make final sales. For instance, a European car sold in the U.S. is bundled with some U.S. services, mainly the wholesale services in getting the car from the port of entry in the U.S. to the dealership and then the dealer's retail services. In another article (2006a), Campa and Goldberg show that these local components mostly matter for the price that the final purchaser pays. (See *Pass-Through to Consumer Prices from Exchange Rates* for more details.) However, these downstream costs can also affect import prices and pass-through. Again, consider the case of a European car manufacturer following an appreciation of the euro. In addition to raising the cost of producing European cars relative to U.S. cars, the appreciation increases the downstream costs of selling cars in Europe relative to the U.S. These differences in downstream costs imply that the price at which the carmaker sells to the dealer will be relatively more important for the final sales price, and hence sales, to consumers in

Pass-Through to Consumer Prices from Exchange Rates

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he consumer price index (CPI) is a weighted average of the prices of goods, based on a standard basket of consumer goods. It is used to measure inflation. Movements in exchange rates are not only passed through to import prices; they can also be passed through to consumer prices. Thus, pass-through to

consumer prices measures the sensitivity of consumer prices to changes in the exchange rate.

José Campa and Linda Goldberg study exchange rate pass-through to import and consumer prices for 21 countries. On average, pass-through to import prices is 64 percent, while pass-through to consumer prices is about 17 percent for these countries. For the U.S., consumer price pass-through is close to zero. However, consumer price pass-through is higher in more open economies, such as the Netherlands (38 percent) and Spain (36 percent). In all cases, though, consumer price pass-through is lower than import price pass-through, indicating that exchange rate movements have a smaller effect on domestic price levels than on import prices.

Consumer price pass-through tends to be lower than import price pass-through because the consumer price index includes only a small share of imported goods. Thus, holding import price pass-through constant across countries, consumer price pass-through tends to be higher in countries that purchase a high share of goods from abroad, since a larger fraction of the consumption bundle in these countries is affected by the exchange rate. However, it is also possible to measure pass-through to consumer prices of individual imported goods. For instance, in a case study of beer, Rebecca Hellerstein finds that pass-through to retail prices on imported beer is only about 11 percent. She attributes this incomplete pass-through to retail prices to three things: incomplete pass-through of import prices by the beer manufacturers; incomplete pass-through by retailers of the price charged by the beer manufacturer; and the presence of wholesale and retail distribution costs that do not change with the exchange rate.

the U.S. than to consumers in Europe. Thus, the carmaker has an incentive to raise its price by less in the U.S. than in Europe.

An alternative, less conventional view is that incomplete pass-through results primarily from difficulties in measuring prices accurately. In this view, the composition of imports may change systematically with the exchange rate. In a third article (2006b), Campa and Goldberg observe

that these composition shifts can change measures of pass-through on aggregate import prices. Shifting imports toward industries with lower pass-through will cause aggregate import pass-through to decline. Likewise, a shift of imports toward industries with higher pass-through will increase pass-through of aggregate prices. Alternatively, a depreciation of the dollar may cause high-price foreign firms exporting to the U.S. to exit,

or buyers may shift their purchases toward lower quality imported goods. For instance, consumers may prefer imported cars with smaller engines or cloth seats rather than leather ones. Measurement of pass-through does not adjust for these changes in the goods being imported to the U.S.

Another possibility is that companies are not accurately reporting the price of international transactions. This is thought to be particularly relevant for those international transactions that occur within divisions of a multinational company, such as when a car manufacturer ships an engine or chassis from a plant in one country to an assembly plant in the U.S. This trade between related parties is very common, accounting for about 50 percent of all imports to the U.S. These transactions are supposed to be booked at market prices, the prices at which unrelated companies would carry out transactions. However, since these prices do not affect trade flows, multinational firms may not be vigilantly updating these prices with the exchange rate or even be aware of market prices. Alternatively, multinationals may choose the price of the transactions to shift profits within the company toward divisions that are in countries with relatively low taxes. In this case, tax considerations matter more for pricing than exchange rate movements do. Indeed, Kimberly Clausing's findings are consistent with this tax-shifting story; she finds that related-party transactions involving U.S. imports are carried out at relatively high prices when the goods are imported from countries with relatively low taxes.

Research has found that each of the reasons described above generates incomplete pass-through. However, since the relevance of these explanations differs across industries and even time periods, the relative

importance of each reason relative to the others remains a question.

WHY PASS-THROUGH MATTERS

To each of us, pass-through clearly matters because it affects our purchasing power at home and when we travel overseas. At the aggregate level, pass-through matters for the conduct of monetary policy and the propagation of business cycles across countries.

Monetary policymakers concerned with the inflationary impact of exchange rate movements focus on pass-through to import prices and subsequently to consumer prices.¹² The importance of pass-through for inflation differs across countries. For instance, in a country that consumes a lot of imported goods, such as New Zealand, where imports make up nearly 40 percent of GDP, pass-through is very important for gauging the inflationary impact of exchange rate movements.¹³ In the U.S., which imports only about 15 percent of GDP and has relatively low pass-through, the influence of exchange rate movements on inflation is smaller. With better measures and models of pass-through, policymakers can better forecast the inflationary impact of exchange rate movements and adjust

¹² See the speech by former Federal Reserve Governor Frederic S. Mishkin at the Norges Bank Conference on Monetary Policy.

¹³ Import ratios are from the Organization for Economic Cooperation and Development's (OECD) Country Statistical Profiles.

monetary policy accordingly.¹⁴

Pass-through is also important for understanding the relationship between economic activity and the exchange rate. When pass-through is high, changes in the exchange rate can have a relatively large effect on

To each of us, pass-through clearly matters because it affects our purchasing power at home and when we travel overseas.

trade flows and thus the trade balance, which is the difference between what a country exports and what it imports. An increase in import prices decreases imports and therefore raises net exports. This movement shifts production to domestic firms, raising demand for workers in the U.S. and lowering it for workers overseas. When pass-through is low, the effect of exchange rate movements on trade flows is much more muted.

Theoretical research, such as that of George Alessandria and that of Caroline Betts and Michael Devereux, finds that incomplete pass-through may actually contribute to larger fluctuations in international relative prices, such as the real exchange rate, over the business cycle. Suppose that the U.S. economy is booming

¹⁴ Joseph Gagnon and Jane Ihrig also present evidence that pass-through tends to be lower for countries with more stable inflation and hence central banks more determined to fight inflation.

and producing a lot of goods. To get consumers to purchase the abundantly available U.S. goods, the U.S. goods must sell for relatively low prices; so there is a tendency for the real exchange rate to depreciate. However, if pass-through is low, within

countries, the price of U.S. goods will fall relatively little compared to foreign goods, and hence, purchases of domestic goods will not rise by much, requiring a much larger movement in the real exchange rate.

SUMMARY

Movements in the exchange rate substantially alter the relative cost of producing goods in different countries. However, consumers in different countries are partly insulated from these movements by the pricing behavior of producers.

Recently, the large depreciation of the dollar has made producing goods outside the U.S. relatively more expensive. This has contributed to rising prices of imported manufactured goods in the U.S. However, the price of imported manufactured goods has risen by substantially less than the cost of producing these goods and the price at which they are sold in the country where they are produced, making these goods a bargain in the U.S. ㊦

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