

DECLINING EXCHANGE RATE PASS-THROUGH TO U.S. IMPORT PRICES: THE POTENTIAL ROLE OF GLOBAL FACTORS

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Abstract

This paper documents a robust and sustained decline in exchange rate pass-through to U.S. import prices, from well above 0.5 during the 1970s and 1980s to around 0.2 over the last decade. We attribute this decline to the rising prominence of competition from China, a shift in import pricing behavior since the Asian financial crisis, and the reduced share of material-intensive goods in U.S. imports. We also find evidence that foreign exporters are increasingly setting their prices with an eye on U.S. prices. These results, in turn, suggest a new and more general hypothesis linking the decline in pass-through to the evolving nature of competition in global markets and structural changes in international production patterns.

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"A consequence of the . . . low pass-through of dollar depreciation to U.S. import prices has been minimal pressure on U.S. consumer price inflation in recent years. A corollary is that the adjustment of U.S. real imports--that is, the quantity of imported goods and services--has been negligible." Alan Greenspan (2005)

1. Introduction

P. Goldberg and M. Knetter (1997), in their comprehensive review of the literature on goods prices and exchange rates, reported that the exchange rate sensitivity of U.S. import prices was typically estimated to be around 0.5 at that time.¹ More recent work, including evidence presented in this paper, indicates that exchange-rate pass-through to U.S. import prices has since moved down markedly. This decline in pass-through has important implications for both U.S. monetary policy and the prospective adjustment of U.S. external imbalances. For example, with little or no pass-through, even a significant drop in the dollar would have only a modest effect on import prices. This, in turn, would have two likely implications. First, consumer price inflation would rise only negligibly following the exchange rate move, reducing the extent of monetary tightening necessary to offset it. Second, the quantity of imports would be reduced by only a small amount, thus limiting adjustment in real net exports.

In this paper, we provide a detailed examination of exchange rate pass-through to U.S. import prices over the last three decades, across categories of imports, and with various bilateral trading partners. We find new empirical evidence that exchange rate pass-through to U.S. import prices has declined from well above 0.5 in the 1970s and 1980s to somewhere in the

¹That is, a 10 percent depreciation of the dollar was associated with an increase in U.S. import prices of about 5 percent.

neighborhood of 0.2 during the last decade. We consider a range of alternative specifications and conclude that the decline in the pass-through coefficient is robust.

While other papers in the literature have noted the decline in pass-through, we document its features more completely and test its robustness more thoroughly than others have done. We also consider a broad set of possible explanations for this decline. Of these explanations, we find little support for two hypotheses that have been put forward: (1) The decline in pass-through is an artifact of shifts in the methodology used to construct import prices, and (2) the decline is largely due to a greater prevalence of short-run pricing rigidities, including the effects of increased exchange rate hedging activity.

Instead, the data better support several other explanations. The first, emphasized by J. Campa and L. Goldberg (2004, 2005) in their watershed studies of import price pass-through in OECD countries, is that the composition of imports has shifted toward goods whose prices are less sensitive to exchange rate movements. Our work indicates that for the United States this phenomenon may explain some, but certainly not the lion's share, of the decline in pass-through over the past several decades.

As a second explanation, we find evidence that in recent years foreign exporters have increasingly set their prices with an eye on the behavior of U.S. domestic prices, consistent with either "pricing to market" or "local currency pricing." This may reflect shifting competitive pressures within U.S. markets or that, as a result of globally integrated production processes, goods imported into the United States now have a higher share of U.S.-made inputs. As outlined in Gust, Leduc, and Vigfusson (2006) and Bodnar, Dumas, and Marston (2002), such developments would help explain the observed decline in pass-through.

We also find evidence for a third explanation, which is closely related to the issues discussed in the previous paragraph. Our results indicate that across categories of U.S. imports, larger increases in China's market share have been associated with more significant declines in pass-through. This has likely reflected not only the effects of direct competition with China, which have made exporters from other countries hesitant to shift their dollar prices in response to moves in their exchange rates, but also the threat of *potential* competition from China. In addition, our work finds that, while pass-through has been decreasing for some time, the fall in pass-through picked up steam around the time of the Asian financial crisis in 1997-98, indicating that the pricing behavior of exporters (not only from China, but also from other countries) has shifted since the crisis.

Taken together, our results point to a new and more general hypothesis linking the decline in pass-through to ongoing structural changes in international patterns of production and global competition. At root, these developments reflect the evolution of technology, reduced transportation costs, declining barriers to trade, and improved macroeconomic policies. We are tempted to call this process "globalization," but we will resist such temptations as the link between globalization and reduced pass-through is far from theoretically settled. We see these issues as providing fertile ground for future theoretical and empirical work.

The remainder of the paper is organized as follows. The next section presents a brief literature review. The following two sections discuss our empirical strategy, present the results from our benchmark specification, and conduct a range of robustness tests. We then assess some explanations for the decline in pass-through. The final section offers some concluding thoughts.

2. Literature Review

In seminal papers, Krugman (1987) and Dornbusch (1987) developed a theoretical apparatus to explain incomplete pass-through to import prices. Both of these papers modeled an oligopolistic market in which a firm's markup is no longer constant and can adjust in response to an exchange rate shock. For instance, following a depreciation of the importing country's currency, a foreign exporter might cut its price in terms of its domestic currency so as to stabilize its price in terms of the importing country's currency. This action could be a defensive response to exchange rate moves that are perceived as temporary (Marston (1990)), or it might result from efforts to maintain market share (Hooper and Mann (1989); Kasa (1992)). These papers, along with the influential work of Knetter (1989, 1993, 1995), provided the basis for the "pricing to market" hypothesis.

A number of recent papers have studied the closely related phenomenon of "local currency pricing." In this framework, an exporting firm sets its price, which may or may not be sticky, in the currency of the country to which it exports. Devereux and Engel (2001) and Bacchetta and van Wincoop (2003), two key papers in this literature, endogenize a firm's choice of invoicing currency and then show that countries with low exchange rate variability or stable monetary policies are more likely to have their currencies chosen for transactions invoicing and, hence, are more likely to manifest low import-price pass-through. Goldberg and Tille (2004) take a somewhat different view. They provide empirical evidence suggesting that the choice of invoicing currency is influenced more by the product composition of a country's exports than by macroeconomic factors.

A host of other hypotheses have also been put forward to explain incomplete and/or declining pass-through to import prices, including greater prevalence of exchange rate hedging (Mann (1986)), shifting product composition of trade (Campa and Goldberg (2004, 2005)), strategic complementarities (Gust, Leduc, and Vigfusson (2006)), and increased cross-border production, which implies that exporters' costs may now be incurred in several currencies (Gron and Swenson (2000) and Bodnar, Dumas, and Marston (2002)). Still other researchers (e.g., Olivei (2002)) have hypothesized that the observed behavior of pass-through may reflect an increasing share of intra-firm transfer prices in the import price indexes. Finally, in an influential paper, Taylor (2000) posits that declining pass-through may owe fundamentally to increasingly anchored inflation expectations arising from improved monetary policy frameworks; this explanation, however, seems to bear more on pass-through to consumer prices than on pass-through to import prices.

On the empirical side, a number of recent papers have found a decline in exchange rate pass-through to U.S. import prices. One of the first was Olivei (2002), who studied disaggregated U.S. import prices for manufactured goods from 1981 to 1999 and found that pass-through to the prices of these goods was about 0.5 on average in the 1980s but declined to 0.2 in the 1990s. Working with panels of industrialized countries, Sekine (2006) and Ihrig, Marazzi, and Rothenberg (2006) find declines in U.S. pass-through that are broadly similar to those observed by Olivei. Campa and Goldberg (2004) enter a dissenting opinion on this issue, however. They split their sample into two periods (1975-87 and 1988-1999), but do not find evidence of a statistically significant shift in exchange rate pass-through to U.S. import prices.

Our paper makes several contributions to this evolving literature. First, we document the decline in U.S. import price pass-through and examine its robustness more thoroughly than others have done. Second, we show how the results in previous empirical papers can be reconciled. In particular, we demonstrate that Campa and Goldberg's non-result is largely an artifact of the particular specification that they estimate. Third, we examine a broad range of explanations for the decline in pass-through in the United States. Our evidence points to the rising prominence of emerging Asia, particularly China, and the shifting features of competition both within the U.S. market and globally as being key explanations.

3. Empirical Strategy and Data Sources

The central question that we study is to what extent movements in the exchange rate and in foreign firms' production costs are reflected in changes in U.S. import prices. In this respect, we follow a framework similar to that developed by Knetter in a series of earlier papers, which may be viewed as the empirical analog of a traditional mark-up pricing model:²

$$(1) \quad \Delta \log(PM_t) = \mu + \beta(L) \Delta \log(CF_t * E_t) + \gamma(L) \Delta \log(PCOM_t) + v_t$$

On the left-hand side of this equation is the log change in dollar-denominated U.S. import prices, denoted PM_t . The first explanatory variable, $CF_t * E_t$, is foreign production costs expressed in dollars. $\beta(L)$ is a lagged polynomial. We take $\beta(1)$, the sum of the contemporaneous and lagged β coefficients, as our estimate of pass-through; these coefficients

²See Knetter (1989, 1993, 1995).

capture the direct effects of exchange-rate adjusted foreign production costs on import prices.³ Of course, changes in the exchange rate also influence import prices indirectly, including through their effects on commodity prices, another important element of firms' production costs. To assess this channel, the second explanatory variable, $PCOM_t$, controls for primary commodity prices; $PCOM_t$ is also expressed in dollars.

We find that pass-through tends to occur quite rapidly, so our specifications include the contemporaneous values and two lags of the exchange rate and foreign prices. Also for this reason, we focus on so-called "long-run" pass-through, i.e., the total effect of the exchange rate on import prices. That said, "short-run" pass-through (the contemporaneous effect) is addressed in our discussion of exchange rate hedging and lag structure in Section 5.2.

Working with a sample running from 1972:Q4 to 2004:Q4, we employ the following data in our empirical investigation. For U.S. import prices (PM_t), we use quarterly observations of NIPA import prices of "core" goods, which exclude oil, computers and semiconductors. We exclude oil prices because of their volatility and computer and semiconductor prices because they are hedonically adjusted and, thus, tend to behave differently than the prices of other imports.⁴ In our work below, we also consider broader measures of U.S. import prices and show that our results do not hinge on the definition of the dependent variable.

³The econometric model that we estimate is somewhat less restrictive than equation (1). We impose a constraint requiring that the sum of the coefficients on the exchange rate be equal to the sum of the coefficients on foreign prices, but we do not constrain the two sets of coefficients to be equal on a period-by-period basis. Our constraint is typically not rejected by the data.

⁴Since the BEA does not publish an import price index for semiconductors, we built a NIPA-basis index using the methodology outlined in Grimm (1998) and published data from the BLS.

Data on foreign production costs (CF_t) do not exist, so the use of proxies is common in the literature. In our benchmark specification, we take foreign headline CPIs as the proxy for production costs because they are available for a broad set of countries and in relatively long time series.⁵ As an alternative, the robustness tests will consider foreign PPIs, although the availability of such data is more limited. For the exchange rate (E_t), we construct a broad index of the dollar's nominal value against the currencies of 35 countries, weighted by rolling bilateral shares of non-oil U.S. imports.⁶ The foreign CPIs are aggregated in a similar manner.

Finally, our baseline specification includes two measures of commodity prices ($PCOM_t$). The first aggregates the IMF's commodity price indexes for food, beverages, agricultural raw materials, and metals, weighting each commodity group by its time-varying share of U.S. imports. The second variable is an index of natural gas prices.⁷ The commodity price effect that we report later in this paper, $\gamma(1)$, is the sum of the coefficients on these two variables.

In the following sections, we estimate rolling regressions (with a fixed 10-year window) to trace a decline in exchange rate pass-through to U.S. import prices. One exercise that we do not undertake is attempting to sort out whether the source of shocks to the exchange rate has changed over time. While this is an analytically important question, such an effort would require strong and potentially controversial identifying assumptions. Instead, our pass-through coefficient should be interpreted as the *average response* of import prices to *all* the shocks that

⁵The fact that CPIs have only limited coverage of primary commodity prices bolsters the case for including commodity prices as a control variable in the regression.

⁶We use non-oil import weights because they are available back to the early 1970s; core import weights are available beginning only in the late 1980s.

⁷Our specifications generally include the contemporaneous value of the commodity price index plus three lags and the contemporaneous value of the natural gas price plus one lag.

hit the exchange rate during a sample period. This pass-through coefficient figures importantly in forecasts of domestic inflation--and hence in the formulation of monetary policy--because the source of exchange rate shocks generally cannot be identified in real time. More broadly, our work documents a robust empirical regularity (i.e., the decline in exchange rate pass-through to import prices) and assesses a range of explanations for that regularity.

4. Benchmark Results and Robustness Tests

4.1 Benchmark empirical results

The upper panel of Figure 1 displays our benchmark estimates of exchange rate pass-through to U.S. core goods import prices as backward-looking ten-year samples are rolled forward. Our estimate of the pass-through coefficient falls from around 0.7 in ten-year samples ending in the 1980s to a bit above 0.5 in samples ending in the mid-1990s.⁸ The pass-through coefficient then begins trending down around the time of the Asian financial crisis (1997-98), until reaching 0.12 in the last ten-year sample. After early 2003, the estimates are no longer statistically significant. These results are consistent with recent research showing that since the Asian crisis export prices from the Asian NIEs (denominated in their local currencies) have shown increased sensitivity to the exchange rate, suggesting reduced pass-through to U.S. import prices.⁹ These results are also consistent with evidence, presented below, suggesting that the rising prominence of China has contributed importantly to the decline in pass-through.

⁸For example, a pass-through coefficient of about 0.7 in 1989:Q4 represents the estimate of $\beta(1)$ in a regression over the period 1980:Q1 to 1989:Q4. It implies that during that period a 10 percent increase in the dollar value of foreign prices eventually led to a 7 percent increase in U.S. core goods import prices.

⁹See Vigfusson, Sheets, and Gagnon (2006).

To further examine these issues, we conduct a formal parameter stability test on our pass-through estimates. We detect a statistically significant structural shift in 1990:Q1, indicating that global competition and production patterns or other factors determining pass-through have changed in important ways since the 1980s.¹⁰ As an alternative perspective, we regress the estimates of $\beta(1)$ reported in the upper panel of Figure 1 on a kinked time trend time that allows the pace of decline in the pass-through coefficient to shift in 1990:Q1 (as suggested by our parameter stability test) and again in 1997:Q3 (to test our impression that the pass-through coefficient began to fall more rapidly near the Asian financial crisis). Using this framework, we find statistically significant kinks both in 1990:Q1 and in 1997:Q3. These results indicate that the pass-through coefficient was relatively stable through the 1980s, that it began to decline early in the 1990s, and that the decline has accelerated since the time of the Asian financial crisis. As such, both this analysis and the formal structural break test suggest that the behavior of pass-through in the years since 1990 has been significantly different than was the case before.

Table 1 underscores the economic implications of these results. In particular, the fourth column of the table shows the results obtained when we estimate our benchmark specification using the full sample, thus restricting the pass-through coefficient, $\beta(1)$, to be constant over the past three decades. A forecast that relied on this regression would expect a 10 percent

¹⁰We performed a recursive Chow test with an unknown break date, drawing the appropriate critical values from Andrews (1993). Specifically, with one restriction and 20 percent of the sample excluded on each side, Andrews reports a 1 percent critical value of 11.69. That is, the null hypothesis of no break in the pass-through coefficient can be rejected if the test statistic (i.e., the supremum of the Chow F-statistics) exceeds this critical value. The test statistic in our case reaches a maximum value of 13.4 in 1990:Q1.

depreciation of the dollar to raise import prices 6.5 percent. This is a dramatically different forecast than would be obtained from a regression estimated over the past ten years (column 3).

The lower panel of Figure 1 shows that for sample periods ending through the past decade, the effect of primary commodity prices on import prices, $\gamma(1)$, has climbed steadily, despite a long-term decline in the import shares of industrial supplies and foods--the most commodity-intensive categories of imports. Notably, our benchmark model is able to explain much of the variance in import prices, with the R^2 for the rolling regressions hovering around 0.8.

4.2 Robustness checks

We now examine the robustness of these results. As noted above, our rolling regressions are done with a ten-year estimation window. The upper panels of Figure 2 show that the decline in pass-through can also be observed when other estimation windows are used. When we take 15-year samples, the pass-through coefficient falls from above 0.6 in the early 1990s to below 0.3 in the most recent 15-year periods. Notably, the decline in the pass-through coefficient begins to accelerate around 1997, as the Asian financial crisis enters the sample window. With a five-year regression window, the pass-through coefficient is volatile but clearly trends down. Notably, the estimates again fall sharply as 1997, the year that the Asian financial crisis rolls into the sample window, and then ebb to near zero during the most recent five-year samples. In light of this evidence, we conclude that the decline in pass-through is not an artifact of our choice of estimation windows.

Independent of the data availability issues noted above, foreign PPIs--as opposed to foreign CPIs--might be a better proxy for the production costs of exporting firms. The lower-left

panel of Figure 2 thus reports estimates identical to those in Figures 1 except that foreign CPIs are replaced with PPIs. The rolling regression results do not go back as far as in the previous regressions, and the foreign price and exchange rate variables include just fifteen countries (weighted by shares of U.S. non-oil imports), rather than the broader set of 35 countries when CPIs are used. Nevertheless, the downward trend in pass-through remains.

As another test of the robustness of these results, the solid line in the lower-right panel of Figure 2 depicts the pass-through estimates obtained when the regression does not control for primary commodity prices ($PCOM_t$). The pass-through coefficient now incorporates the indirect effects of exchange rate moves working through commodity prices. The downward trend in pass-through since the early 1980s remains.¹¹ That said, relative to our benchmark estimates from Figure 1, the pass-through coefficient in this regression starts higher--at 0.8 or above for ten-year samples ending in 1983-85--and then falls in the most recent ten-year period to a little over 0.3, still somewhat above the benchmark estimates. Notably, the pass-through coefficient again steps down around the time of the Asian financial crisis.

In contrast to our benchmark results, the pass-through coefficients obtained when commodity prices are not controlled for in the regression have moved down only modestly further in ten-year samples ending over the past four or five years. The fact that pass-through estimated without controlling for commodity prices has been somewhat more stable of late is a recurrent feature of our empirical work and suggests that an increasing share of the exchange rate's effects on import prices has occurred indirectly through commodity prices. The increased

¹¹As with our benchmark model, the recursive Chow test outlined above finds evidence of a statistically significant break in the pass-through coefficient for this specification.

importance of this commodity-price channel reflects (at least in part) that commodity prices themselves have become more sensitive to the exchange rate in recent years.¹²

In addition to the robustness checks reported in this section, we have also explored a number of other specifications, including estimating our benchmark model in levels rather than in first differences, adding a lagged dependent variable to the regression, expressing commodity prices in terms of foreign currency rather than in dollars, and removing the constraint requiring the sum of the coefficients on the exchange rate to be equal to the sum of the coefficients on foreign prices. All of these specifications yield reductions in pass-through that are broadly similar to those reported in this section. Our conclusion is that the observed decline in pass-through is robust.

4.3 Considering broader measures of import prices

The fall in pass-through depicted in Figure 1 is not specific to only core goods import prices. As shown in Figure 3, the decline is virtually identical when our benchmark model is estimated with non-oil goods import prices as the dependent variable. As such, the inclusion or exclusion of computers and semiconductors does not materially affect our results.

Sekine (2006) and Campa and Goldberg (2004, 2005) take the import prices of all goods as their dependent variable.¹³ (Both papers work with panels of countries, and more narrow measures of import prices are not available for some of the countries they study.) However, Sekine controls for the price of oil and other commodities on the right-hand side of his

¹²We examined this issue directly using our rolling regression framework. We found that our index of commodity prices has become more sensitive to the exchange rate, although the estimated coefficients are somewhat volatile.

¹³Olivei (2002) works with a set of U.S. manufacturing industries, which is broadly similar to the “finished goods” sectors that we study in Section 5.3.

regressions, while Campa and Goldberg do not. This proves to be a crucial difference in their analysis, which explains why Sekine finds significant decreases in pass-through for the United States and why Campa and Goldberg see no such reduction. When our regressions control for oil and other commodity prices, pass-through to total import prices declines in a manner similar to that of more narrow measures of import prices. When such controls are not included, pass-through remains higher and is quite volatile. The behavior of oil prices plays a central role in these results. In particular, our work suggests that the decision to neither exclude oil import prices from the dependent variable nor control for them on the right-hand side of the regression allows the behavior of oil prices to mask the broad decline in pass-through that has occurred.¹⁴

5. Some Explanations for the Decline in Import Price Pass-through

5.1 Changes in the methodology used to construct import prices

Since the early 1980s, NIPA import prices have been constructed mainly using import price surveys published by the BLS. Before then, NIPA import prices were based on Census unit value indexes. For some, this has raised concerns that the reported declines in pass-through may be an artifact of how the data are constructed, rather than a shift in underlying economic behavior. To assess this possibility, we ran a regression using the BLS measure of non-oil goods import prices as our dependent variable (since this series did not experience the methodological change noted above).¹⁵ The results are depicted by the dashed line in the lower panel of

¹⁴The exchange rate sensitivity of oil prices is an important question; however, given the unique features of global oil markets and the volatility of oil prices, it is one that is best modeled explicitly, rather than aggregating oil into a broad import-price equation. Notably, Campa and Goldberg (2004) observe that in their sectoral pass-through regressions, energy prices “have the most anomalous behavior among all product categories, with country estimated pass-through coefficients varying considerably.”

¹⁵We use the price of non-oil goods imports because the BLS does not publish a measure of core import prices.

Figure 3. Given that the dashed line closely tracks the solid line (its NIPA counterpart from the upper panel), we rule out this shift in methodology as an explanation for the observed decline in pass-through.

A similar hypothesis put forward, for example, by Olivei (2002) is that the decline in pass-through may reflect an increased prevalence of intra-firm “transfer prices.” Before 1998, only transfer prices that were seen as sufficiently market-based were included in the BLS indexes of import prices. Since then, all transfer prices have been included. The available evidence, however, weighs strongly against this hypothesis. Clausing (2001), the most detailed empirical paper on this topic, finds that intra-firm import prices are stickier than arms-length import prices in the short run, but--once they ultimately adjust--transfer prices are actually *more* responsive to the exchange rate.¹⁶ This pattern of results may be explained as follows. With tax and customs officials enforcing legal requirements that transfer prices satisfy an “arm’s length” standard, many firms adjust their transfer prices using mechanical rules, which incorporate a relatively large response to the exchange rate. However, because such adjustments happen only periodically, pass-through to transfer prices may occur less rapidly than is the case for other import prices.

5.2 Exchange rate hedging: Is there evidence of longer lags?

Because exchange rate hedging has become more prevalent in recent years, we might very well find evidence of longer lags from changes in exchange rates to changes in import prices. Such hedging strategies should give foreign firms increased scope to maintain their

¹⁶Gopinath and Rigobon (2006) also find that transfer prices are somewhat stickier than other import prices.

dollar prices in the face of exchange rate moves, at least until the hedges begin to roll off. In addition, as observed in the previous section, the BLS's increased use of transfer prices in constructing its import price indexes might lengthen the lags between exchange rate moves and the response of import prices. To explore these possibilities--as well as to shed further light on the features of our econometric specification--Figure 4 focuses on the lag structure of our benchmark pass-through estimates presented in Figure 1.

As displayed in the upper panel, in our benchmark specification, which includes the contemporaneous change in the exchange rate and two quarterly lags, we observe a sustained decline in all three coefficients. The contemporaneous coefficient (sometimes called "short-run" pass-through) falls from about 0.4 to around 0.1; the first lag falls from about 0.2 to just above zero; and the second lag, although volatile initially, falls from just under 0.2 to near zero in ten-year samples ending in 1998 and thereafter. The lower panel shows results for an alternative specification that includes the contemporaneous exchange rate and four lags. Notably, the results for the contemporaneous change and the first two lags are quite similar to those in the upper panel. The estimates for the third and fourth lag are initially negative and thereafter hover near zero.

Taken together, these results indicate that exchange rate pass-through occurs quite rapidly; in recent years, pass-through appears to have occurred with only a one quarter lag. As such, we do not find evidence to support the hypothesis that hedging activities or the increased use of transfer prices have lengthened the lags between exchange rates changes and moves in import prices. More generally, given that over the entire sample period, the contemporaneous coefficient and the first lag have accounted for the lion's share of exchange rate pass-through,

these results suggest that short-term pricing rigidities are not driving our results. (If such rigidities were an important part of the story, the lagged effects would be large relative to the immediate response, as firms adjusted their prices over time.)

5.3 Shifting product composition of U.S. imports

Since the 1970s, the share of non-oil industrial supplies and foods and beverages in U.S. core imports has moved down from over 40 percent to about 25 percent at present.¹⁷ The declining share of these commodity-intensive goods--for which pass-through is likely to be relatively high--is a potential explanation for the fall in pass-through. Accordingly, this section uses our benchmark specification to estimate pass-through coefficients for individual categories of core imports, dis-aggregated according to one-digit end-use codes. As a first step in this exercise, we construct exchange rate and foreign CPI variables that are industry specific--that is, they take as weights each trading partner's bilateral share of U.S. imports in each category.¹⁸

Figure 5 shows the results of this exercise. Notably, pass-through estimates for the "finished goods" sectors--consumer goods, capital goods, and automotive products--all post steep declines whether or not controls for commodity prices are in the regressions.

In contrast, the pass-through estimates for the "material intensive goods"--non-oil industrial supplies and foods and beverages--do depend on the specification. The estimates fall markedly when controls for commodity prices are included on the right-hand side. However, when such controls are not included, the pass-through estimates for these sectors are much

¹⁷In contrast, the import shares of capital goods and consumer goods have each posted sizable gains since the 1970s, while the share of automotive products is little changed on balance.

¹⁸These product-specific cross-country weights are available starting in 1989; for earlier years, the weights are fixed at their 1989 average values.

higher and--if anything--have stepped up in recent years. These results indicate that the exchange rate's effects on the prices of imported industrial supplies and foods and beverages have come principally through its indirect effect on commodity prices. This is consistent with the commodity-intensive nature of these goods.

Figure 6 explores the implications of these results for aggregate pass-through. In the upper panel, the solid line is our benchmark pass-through estimate from Figure 1, and the dotted line is a weighted average of the one-digit sectoral pass-through estimates from the upper panels of Figure 5. (The weights used reflect each category's rolling share of nominal imports over the preceding ten years.) As expected, the weighted-average of our sectoral pass-through estimates is close to the estimate of aggregate pass-through. The dashed line is obtained by again weighting up the one-digit sectoral pass-through estimates from the upper panels of Figure 5, but in this instance using average trade shares from 1972 to 1982 as fixed weights. If the fall in aggregate pass-through largely reflects a shift in the composition of imports toward goods whose prices are less sensitive to the exchange rate, the dashed line would remain relatively stable and above the solid and dotted lines. However, this has not occurred--the dashed line closely tracks the dotted line, and both lines follow the solid line. Thus, with controls for commodity prices in place, the shifting composition of U.S. trade cannot explain any of the decline in pass-through.

The lower panel of Figure 6 repeats this exercise using the coefficients obtained when the regressions do not control for commodity prices. The solid line is the estimate of aggregate pass-through from the lower-right panel of Figure 2, i.e., the benchmark model with controls for commodity prices excluded. The dotted line is an average of the sectoral pass-through estimates from the lower panels of Figure 5 calculated using rolling trade weights, while the dashed line

aggregates the same sectoral pass-through estimates using average trade shares from 1972 to 1982 as fixed weights. In this instance, the dashed line falls on balance but has been above the solid line by 0.1 or so in the most recent ten-year samples. The divergence between these two lines indicates the extent to which the changing product composition of U.S. imports has contributed to the decline in pass-through (once the exchange rate's indirect effects through commodity prices are incorporated into the pass-through coefficients).¹⁹ As such, the shifting composition of core imports may explain some--but certainly not the lion's share--of the fall in aggregate pass-through over the past several decades, and other factors are clearly also at work.

5.4 Geographical composition of U.S. imports

Another potential explanation for the decline in pass-through to U.S. import prices is a shift in the geographical orientation of imports toward countries that manifest lower exchange rate pass-through.²⁰ With this issue in mind, we use data on bilateral U.S. import prices published by the BLS to estimate country- or region-specific pass-through coefficients. These coefficients capture, for each country or region, the sensitivity of the prices charged in the U.S. market to movements in the nominal value of their currencies against the dollar as well as to shifts in their domestic CPIs. Such bilateral import price data are available since the early 1990s

¹⁹Similarly, working with a set of industries that includes oil, Campa and Goldberg (2005) find that the shifting product composition of U.S. imports--holding all else equal--would have reduced the pass-through coefficient for the United States by 0.11 between 1980 and 2002. They do not reconcile this result with their work indicating that pass-through to U.S. import prices has not declined.

²⁰Exporters from one country may evidence lower pass-through than exporters from another country as a result of differences in the composition of the goods that they export. We conjecture that differences in exchange rate regimes, the extent of domestic financial sector development, and general supply and demand conditions in the home market might also play a role.

for the European Union, Japan, Canada, and the Asian NIEs.²¹ Given the relatively short time series, we cannot do rolling regressions as we have done above. Also, since bilateral prices for core (or non-oil) imports are not published, these data are import prices for all goods.

Our results, reported in Table 2, indicate that for a sample beginning in the early 1990s exchange rate pass-through from all four sets of trading partners has been quite low. In Specification 1, the results for the European Union, Japan, and the Asian NIEs are all strikingly similar, with the estimated pass-through coefficients a touch above 0.2 and the commodity price coefficients near 0.1. The general features of the pass-through results for these three economies do not depend on whether commodity prices are included or excluded from the regressions. In contrast, the pass-through estimate for Canada swings from essentially zero when commodity prices are included in the regression to over 0.3 when commodity prices are excluded, reflecting the importance of commodities in Canadian exports. Finally, we note that all of these pass-through estimates are well below the values of 0.5 or higher that are obtained with U.S. aggregate data for the preceding decades. Thus, a shift in the geographical orientation of trade can--at best--be only a partial explanation for the decline in pass-through.²²

5.5 Are U.S. import prices now more sensitive to moves in domestic prices?

Thus far, our empirical work has focused on estimating traditional mark-up style equations. In this section, we extend the discussion by allowing the prices set by exporting firms

²¹These four sets of trading partners have accounted for about 60 percent of both U.S. total imports and U.S. non-oil imports over the past decade. The Asian NIEs include Hong Kong, Korea, Singapore, and Taiwan.

²²This conclusion broadly parallels results reported in Gopinath and Rigobon (2006) which indicate that the increased stickiness of U.S. import prices cannot be explained by a shift in the geographical composition of imports.

to respond to the prices of their competitors in the U.S. market, consistent with either “pricing to market” or “local currency pricing.” In particular, we consider the following extension of our benchmark model:

$$(2) \quad \Delta \log(PM_t) = \mu + \beta(L) \Delta \log(CF_t * E_t) + \gamma(L) \Delta \log(PCOM_t) + \delta(L) \Delta \log(PC_t) + v_t$$

where PC_t is the dollar price charged by competing firms in the U.S. market and is proxied by the contemporaneous U.S. PPI.

This framework is similar to that derived by Feenstra, Gagnon, and Knetter (1996) using a model in which firms engage in Bertrand competition and, thus, set their prices with an eye toward the prices charged by their competitors. More recently, Gust, Leduc, and Vigfusson (2006), drawing on the work of Kimball (1995) and Dotsey and King (2005), show within the context of a DSGE model that in the presence of strategic complementarities--that is, if a firm's optimal price response depends positively on the price set by its competitors--exporting firms will not want their prices to move too far from their competitors' prices. Important for our purposes, the papers by both Feenstra, Gagnon and Knetter and Gust, Leduc, and Vigfusson feature a homogeneity condition in which the coefficients on firms' production costs and on competitors' prices sum to one. (In our framework, this is analogous to requiring, $\beta(1) + \gamma(1) + \delta(1) = 1$.) Thus, in these papers, an increased sensitivity to competitors' prices necessarily brings with it a decline in exchange rate pass-through.

U.S. domestic prices, in addition to serving as a proxy for competitors' prices, may influence the prices charged by foreign exporters through an additional channel. Given the increasing prevalence of offshoring and other vertically fragmented global production processes, goods imported into the United States very likely have a higher share of U.S.-made or dollar-

denominated inputs that was the case fifteen or twenty years ago.²³ This creates a natural hedge, which as shown in Gron and Swenson (2000) and Bodnar, Dumas, and Marston (2002), tends to reduce import price pass-through, while the presence of significant U.S. value added means that import prices should more closely track U.S. domestic prices.

To examine these hypotheses empirically, we estimate equation (2) using our rolling regression framework. As shown in the upper-left panel of Figure 7, both the pass-through coefficient and the coefficient on the U.S. PPI are volatile in ten-year samples ending in the 1980s. In subsequent ten-year samples, however, the behavior of the pass-through estimate is very similar to our benchmark results. The coefficient on the U.S. PPI is close to zero and statistically insignificant through the 1990s and early this decade, but has risen in recent ten-year samples and is statistically significant at the end of the sample period. The upper-right panel reports estimates from a regression that does not control for commodity prices. The results broadly confirm those in the upper-left panel. Notably, however, the coefficient on the U.S. PPI in recent ten-year samples is larger in magnitude and more strongly statistically significant than in the upper-left panel.

²³ Although reports of such offshoring activities are now common, the data describing this phenomenon are still only fragmentary (see National Academy of Sciences (2006)). Several observations are suggestive, however. First, Chen, Kondratowicz, and Yi (2005) show that exports by U.S. multinationals to their affiliates abroad of goods for further processing increased from 15.6 percent of total U.S. exports in 1977 to 21.9 percent in 1999 (the last year for which data are available). In addition, the share of exports in the total sales of these foreign affiliates rose from 31.1 percent in 1977 to 41.1 percent in 1999. While such exports may go anywhere in the world, many are likely to return to the United States. (Of course, this gives only a partial reading on this phenomenon because “round-tripping” of U.S. made inputs may also occur through transactions between unrelated firms.) Second, Chen, Kondratowicz, and Yi also report that the U.S. content of U.S. imports from Mexico and from Canada’s motor-vehicle industry in 2000 was equal to \$97 billion or more than one-quarter of total U.S. imports from these two countries, compared with less than \$20 billion or one-sixth of total U.S. imports from these countries in 1990 (see Hummels, Ishii, and Yi (2001)). The data necessary to do similar calculations for U.S. trade with other countries are not available.

As noted above, papers in the literature have sometimes incorporated a homogeneity condition on the right-hand side variables. As shown in the lower-left panel, when we impose this restriction on equation (2), we continue to see somewhat volatile coefficients for samples ending in the 1980s. The pass-through estimates then hover between 0.6 and 0.7 through most of the 1990s, while the coefficient on U.S. domestic prices is below 0.3. However, starting in the late 1990s, the coefficient on U.S. prices begins a dramatic rise, while the pass-through coefficient declines. In our last ten-year sample, the coefficient on the U.S. PPI is roughly twice as large as the pass-through coefficient. The results are similar when the regressions do not control for commodity prices.

To explore these issues further, we again turn to the bilateral U.S. import price data discussed in the previous section. We examine whether exporters from one country tend to be more sensitive to U.S. domestic prices than exporters from other countries. Estimating equation (2) using these data, we find that the coefficient on the U.S. PPI is particularly large and statistically significant in regressions explaining the price of U.S. imports from Canada. Given Canada's deep integration with the U.S. economy and the abundance of vertically specialized trade (most notably in the auto sector), it is not surprising that the prices charged by Canadian exporters show marked sensitivity to U.S. domestic prices. This result does not depend on whether or not the regression controls for commodity prices.

Taken together, the evidence presented in this section points to a recent shift in the pricing behavior of foreign firms in the U.S. market. These results are consistent with the hypothesis that exporters to the United States are increasingly setting their prices with an eye toward the prices of their domestic competitors and/or that the U.S. value-added in U.S. imports

has increased. We emphasize, however, that these results are only suggestive. One open empirical issue is that including the U.S. PPI in the specification may create a simultaneity problem--the U.S. PPI helps explain the behavior of U.S. import prices, but U.S. import prices may also affect the evolution of the PPI.²⁴ To address this issue, we estimated models that instrumented for the PPI. We found, however, that the features (and statistical significance) of the results depended on the specification that was estimated and the choice of instruments. We see the issues discussed in this section as meriting further exploration in future research.

5.6 Has competition from China contributed to the decline in pass-through?

Over the past decade, China's share of U.S. non-oil imports has risen 9.7 percentage points, from 6.6 percent in 1994 to 16.3 percent in 2004.²⁵ If U.S. imports from China showed zero pass-through and if imports from countries losing import share showed complete pass-through, the direct arithmetic effect of China's increased presence in the U.S. market would be to lower the aggregate pass-through coefficient by 0.097, only a fraction of the observed decline. And this calculation likely overstates the effects that have occurred through this channel: In those product categories where China has gained the most ground, import shares for Japan and the emerging Asian economies have typically experienced the largest losses; as was shown in the previous section, pass-through from these economies is much closer to zero than to unity.

This discussion indicates that increases in China's share of U.S. imports can directly account for only a small portion of the decline in pass-through. Nevertheless, China's rising

²⁴That said, because the PPI captures the prices that domestic firms receive for their products, imports are not explicitly included in the PPI, as is the case with the CPI.

²⁵Because China has gained significant market share in computers and semiconductors, we see these sectors as highly relevant to the hypotheses considered in this section; for this reason, we include them in our empirical work. The results, however, are similar when these sectors are excluded.

presence in U.S. markets may very well be associated with the fall in pass-through through other channels. First, efforts to remain competitive against China may have affected the pricing decisions of exporters from other countries. In 2004, China's import share exceeded 50 percent in six five-digit end-use categories and 25 percent in another fifteen categories. (Together, these twenty-one categories represent about one-quarter of U.S. non-oil imports.) Certainly in these categories, exporters from other countries have had good reason to be hesitant to pass through cost shocks from the recent appreciation of their currencies against the dollar, given that China's exchange rate regime has insulated its exporters from such shocks.

Second, China's effects on pricing behavior likely extend well beyond product categories in which Chinese firms already have a significant presence. Chinese producers have shown a remarkable propensity to win market share, with their exports posting large gains in both simple, commodity-like products and in more sophisticated products. Thus, even in those categories in which China does not already account for a significant fraction of U.S. imports, the threat of potential competition from China may have been a factor constraining other exporters from passing through exchange rate shocks.

More generally, increases in China's share may not only reflect the impact of China *per se* but may also capture even deeper factors driving shifts in global competition and production patterns. For example, improved transportation technologies or reduced trade barriers in a given sector may have contributed to the decline in pass-through directly,²⁶ and may have also given U.S. firms increased scope to source their products from China.

²⁶See Gust, Leduc, and Vigfusson (2006).

In line with these hypotheses, Figure 8 provides some empirical evidence linking China to the decline in pass-through. For the 1985-1994 and 1995-2004 periods, we estimate separate pass-through coefficients for 34 five-digit import categories and--where five-digit price data are not available--another 22 two- and three-digit categories.²⁷ Together, these 56 categories account for more than 80 percent of U.S. non-oil imports. We find a statistically significant correlation between the rise in China's U.S. import shares over the past decade and the decline in pass-through across these product categories, with a t-value on the slope coefficient of -2.35. In other words, pass-through has tended to post relatively steep declines in those categories in which China has expanded its market share most rapidly. For example, in categories where China's import share has risen more than 10 percentage points since 1994, the median decline in the pass-through coefficient was 0.341 versus a median decline of 0.157 in other categories. The difference in mean declines is even more striking--0.362 in those categories in which China's share grew at least 10 percentage points versus a mean change of zero in other categories. We replicated this exercise for Mexico, another emerging-market country that has gained U.S. import share over the past decade, but did not find a significant relationship.

Our work examining the robustness of this correlation between the gains in China's share and the decline in pass-through indicates that most of this association comes as a result of the differential pass-through performance of finished goods imports compared with material-intensive goods imports (which emerges when the pass-through coefficients incorporate the indirect effects of exchange rate moves through commodity prices). China's import share posted

²⁷To do so, we use BLS import prices--rather than NIPA prices--as they are available on a more disaggregated basis. Also, it is not clear how to appropriately specify the commodity price variables for each of these disaggregated sectors, so the regressions do not control for commodity prices.

an average increase over the last decade of 13.3 percentage points in the former categories but of only 4.3 percentage points in the latter categories. This suggests that the relatively rapid increase in China's presence in the finished goods categories may have been one factor contributing to the greater decline in pass-through observed in those categories.

6. Conclusions

This paper has provided new evidence documenting a decline in exchange rate pass-through to U.S. import prices, from well above 0.5 in the 1970s and 1980s to somewhere around 0.2 over the past decade. Because import prices are a principal channel through which the exchange rate affects domestic prices, this shift in the pass-through coefficient has important implications for the behavior of U.S. inflation and, hence, for the stance of monetary policy. In addition, the degree to which import prices respond to the exchange rate is likely to be a crucial factor influencing the adjustment of the gaping U.S. external deficits, with reduced pass-through necessitating a larger depreciation of the dollar.

Our work points to several complementary explanations for this decline. First, we find evidence that the reduced import share of material intensive goods--the prices of which are quite sensitive to the exchange rate (once indirect effects through commodity prices are taken into account)--explains a fraction of the fall in aggregate pass-through. Second, foreign exporters may be increasingly setting their prices with an eye on the behavior of U.S. domestic prices, consistent with "pricing to market" or "local currency pricing." Third, China's rising prominence in the U.S. market appears to be another piece of the story, as direct competition from China, as well as the threat of potential competition from China, has affected the pricing behavior of foreign exporters.

Together with our observation that the pass-through coefficient steps down around the time of the Asian financial crisis, these results point to a new and more general hypothesis linking the decline in pass-through to the evolving nature of competition in global markets and structural changes in international patterns of production. At root, these developments reflect the evolution of technology, reduced transportation costs, declining barriers to trade, and improved macroeconomic policies.

The key remaining question regards the durability of the decline in pass-through, but we cannot answer this question with much confidence. On the one hand, the forces of global integration and competition that seem to be driving the decline are unlikely to abate. On the other hand, in order to maintain market share, exporting firms may be willing to accept narrowing margins for some time, but this is unlikely to continue indefinitely. Thus, given a large enough depreciation of the dollar, foreign firms will presumably need to raise their dollar prices eventually or exit the U.S. market.

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Figure 1

The Secular Decline in Pass-through to U.S. Import Prices

Benchmark Results

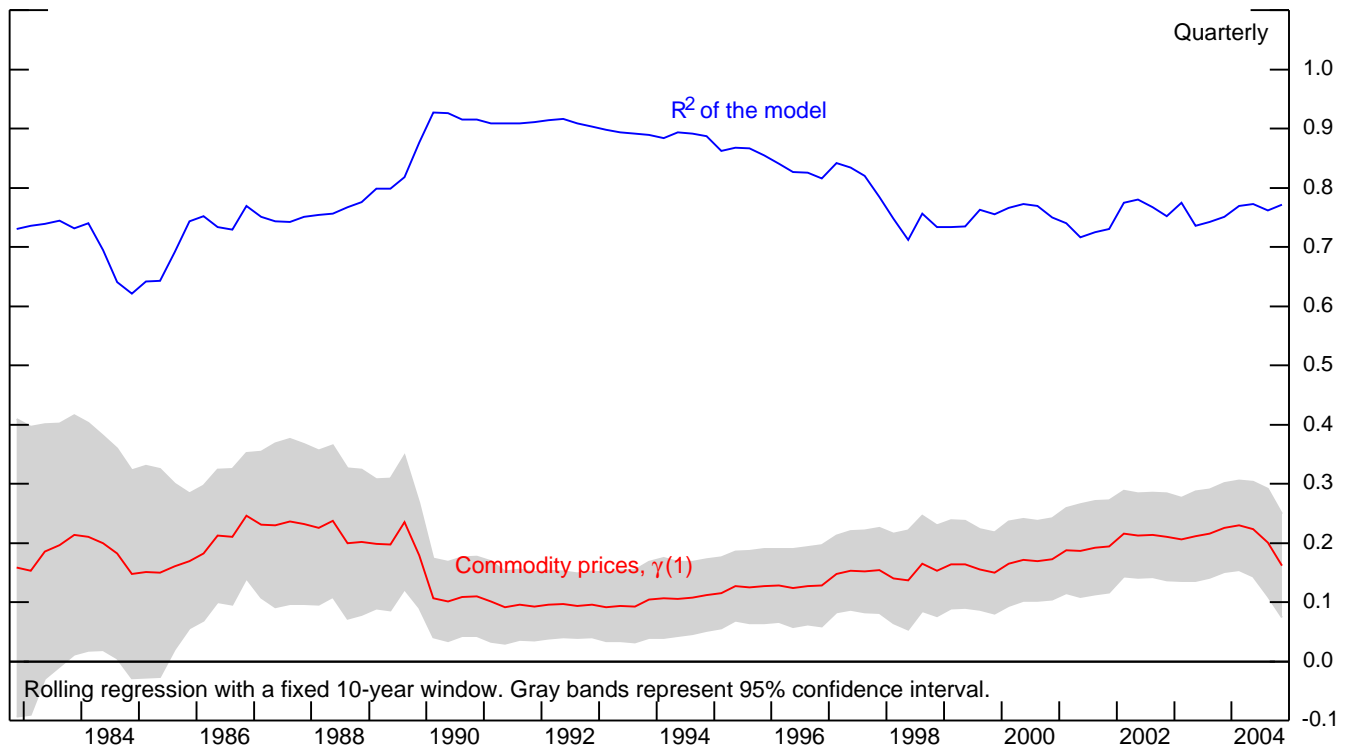
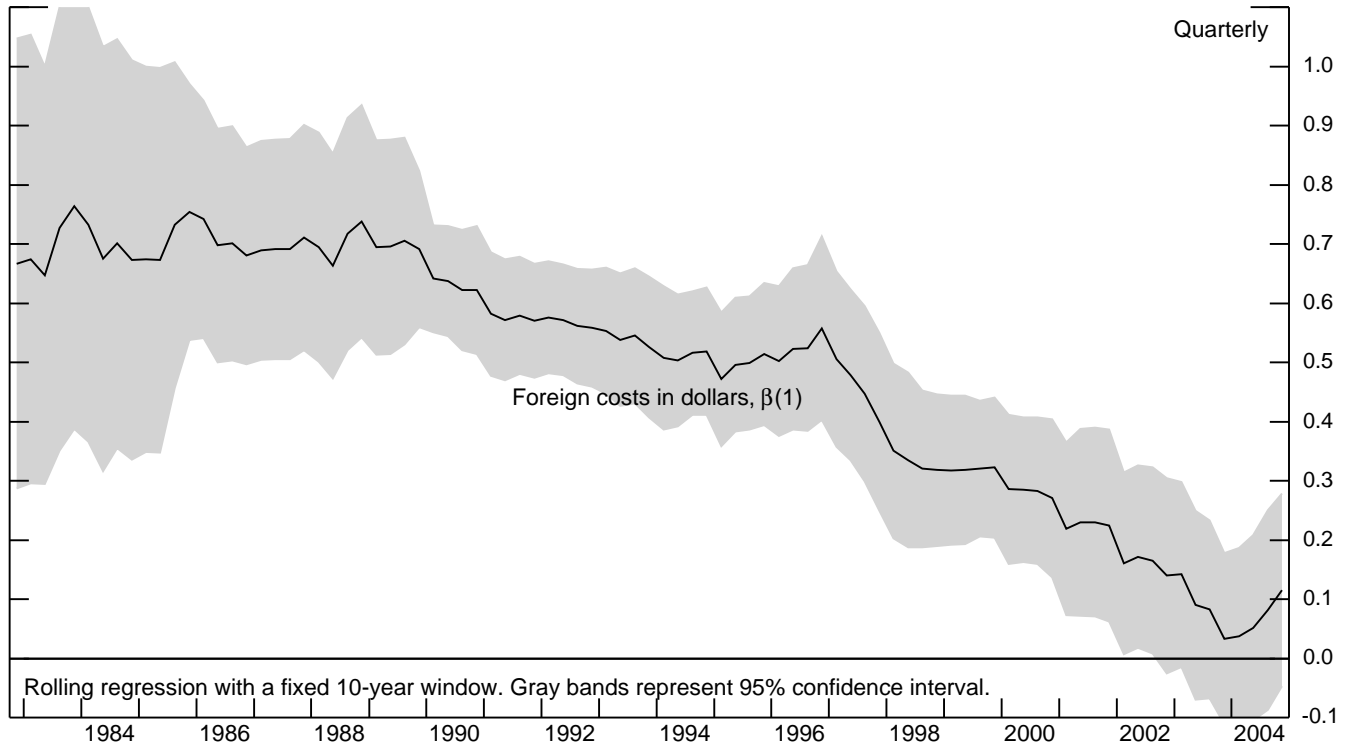
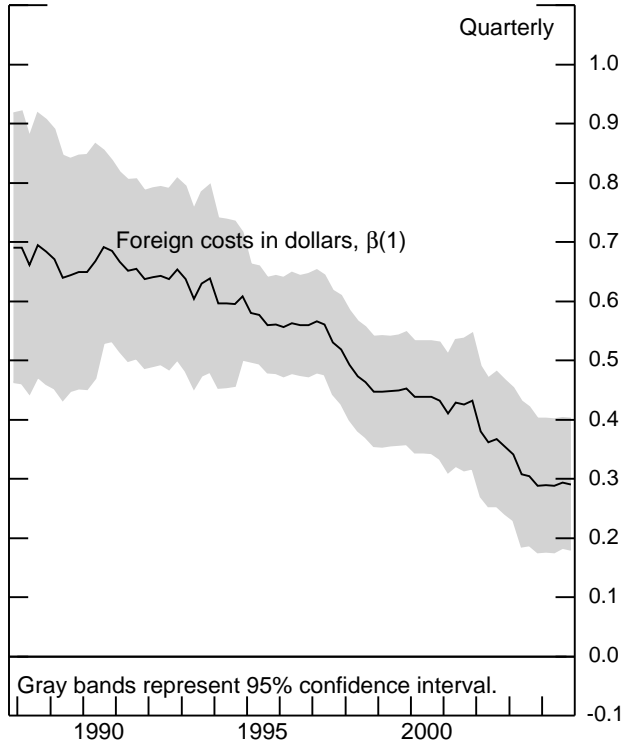


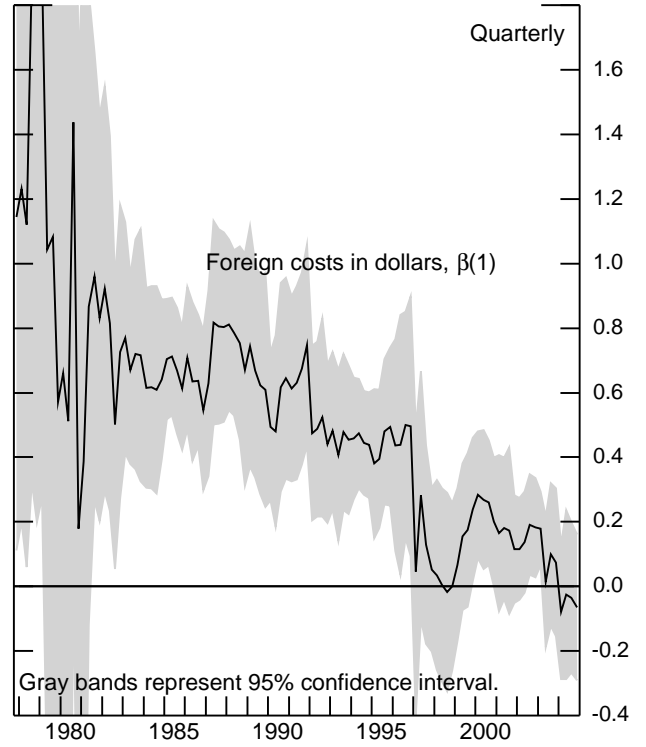
Figure 2

Robustness Tests

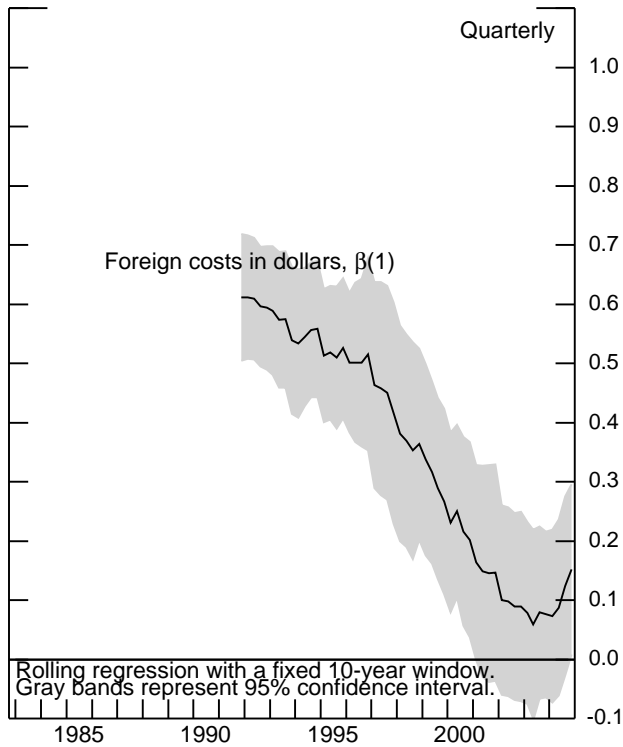
Rolling Regression with a Fixed 15-year Window



Rolling Regression with a Fixed 5-year Window



Using Foreign PPIs, instead of CPIs



Without Controls for Commodity Prices

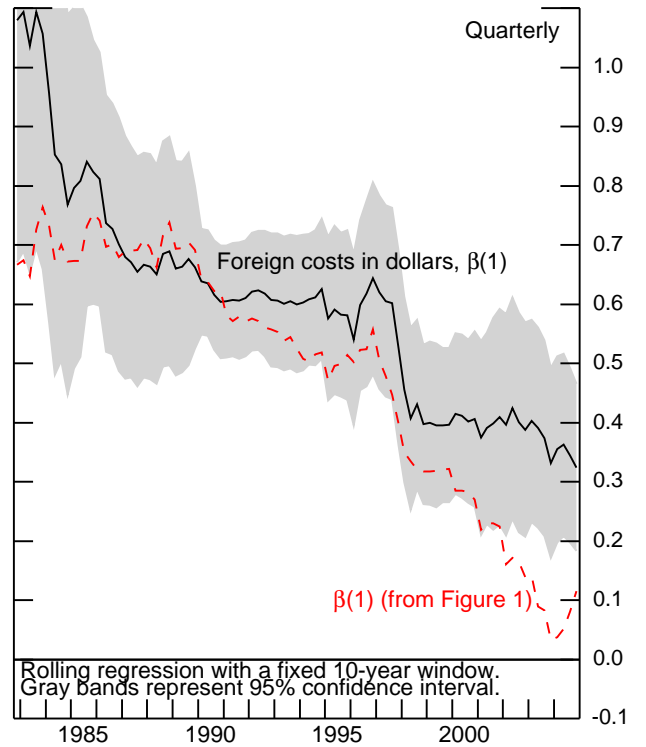
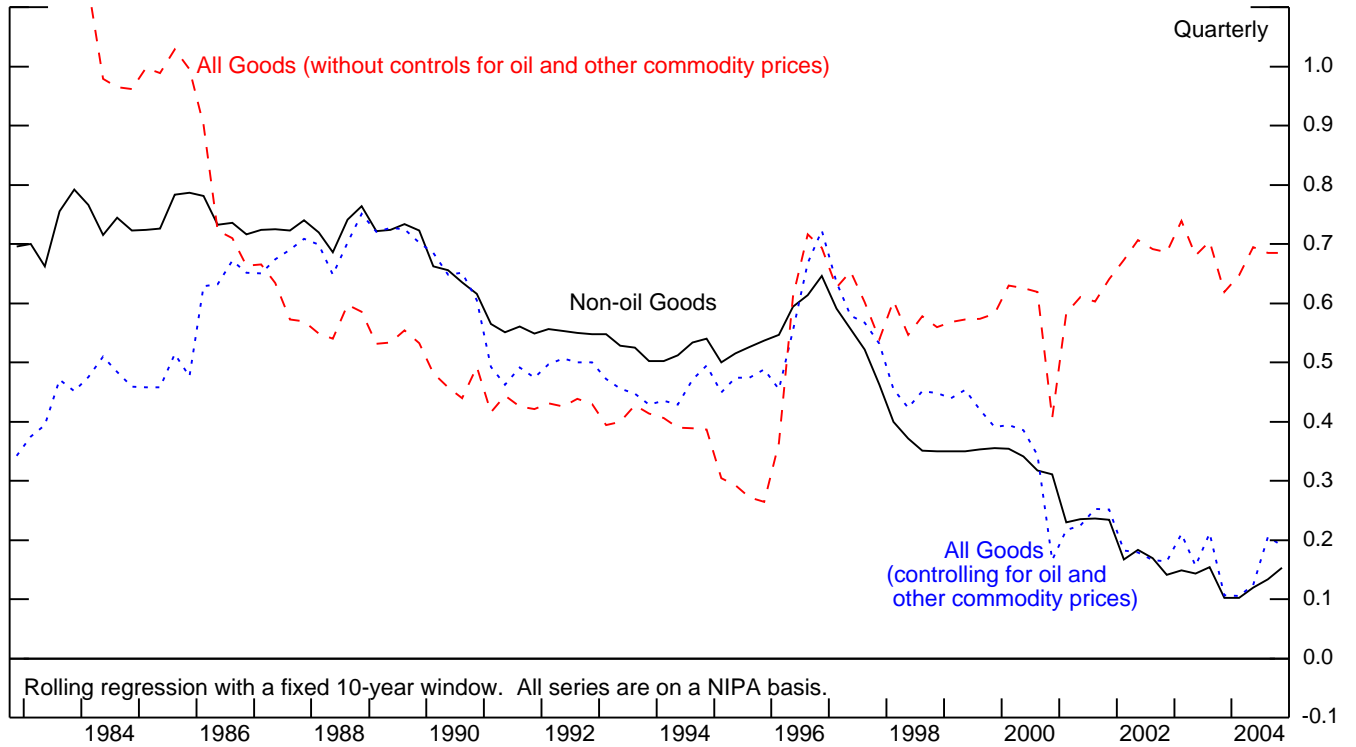


Figure 3

Pass-through to Broader Measures of U.S. Import Prices



Do Changes in Data Methodology Explain the Decline in Pass-through?

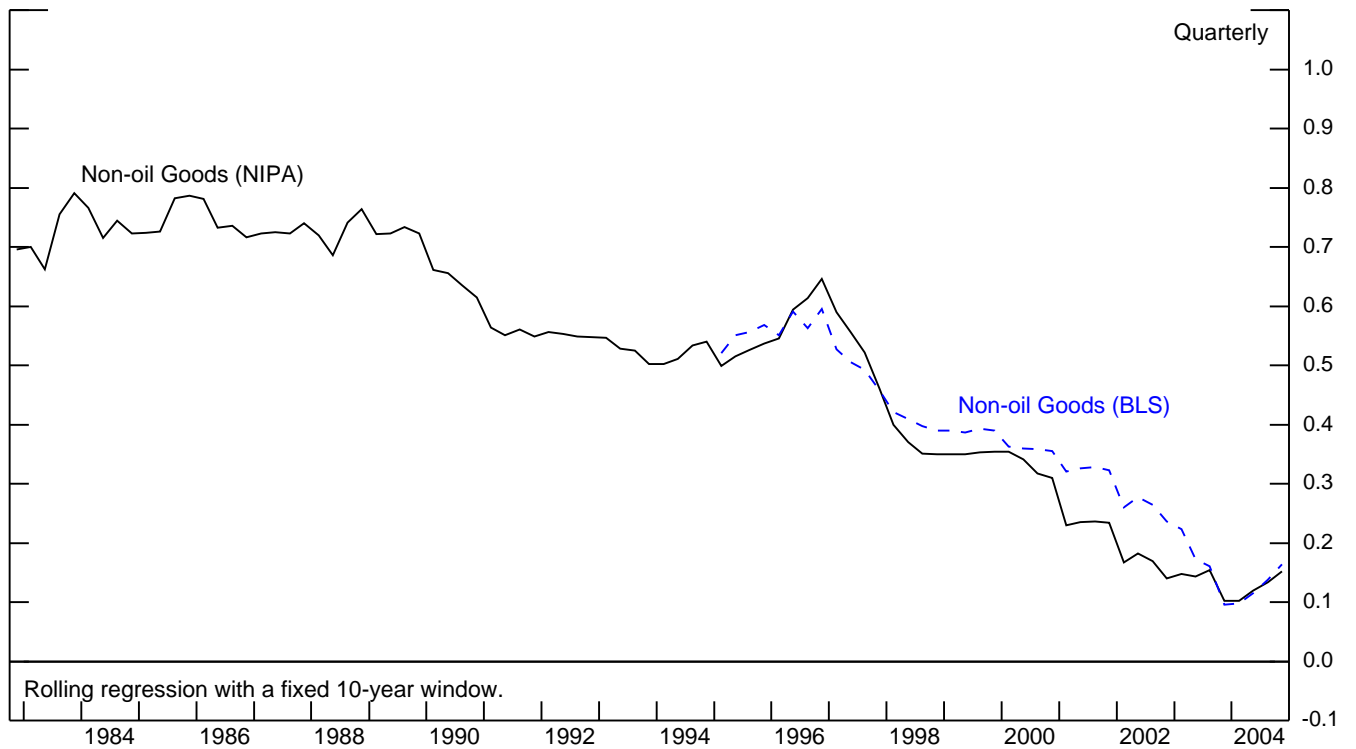
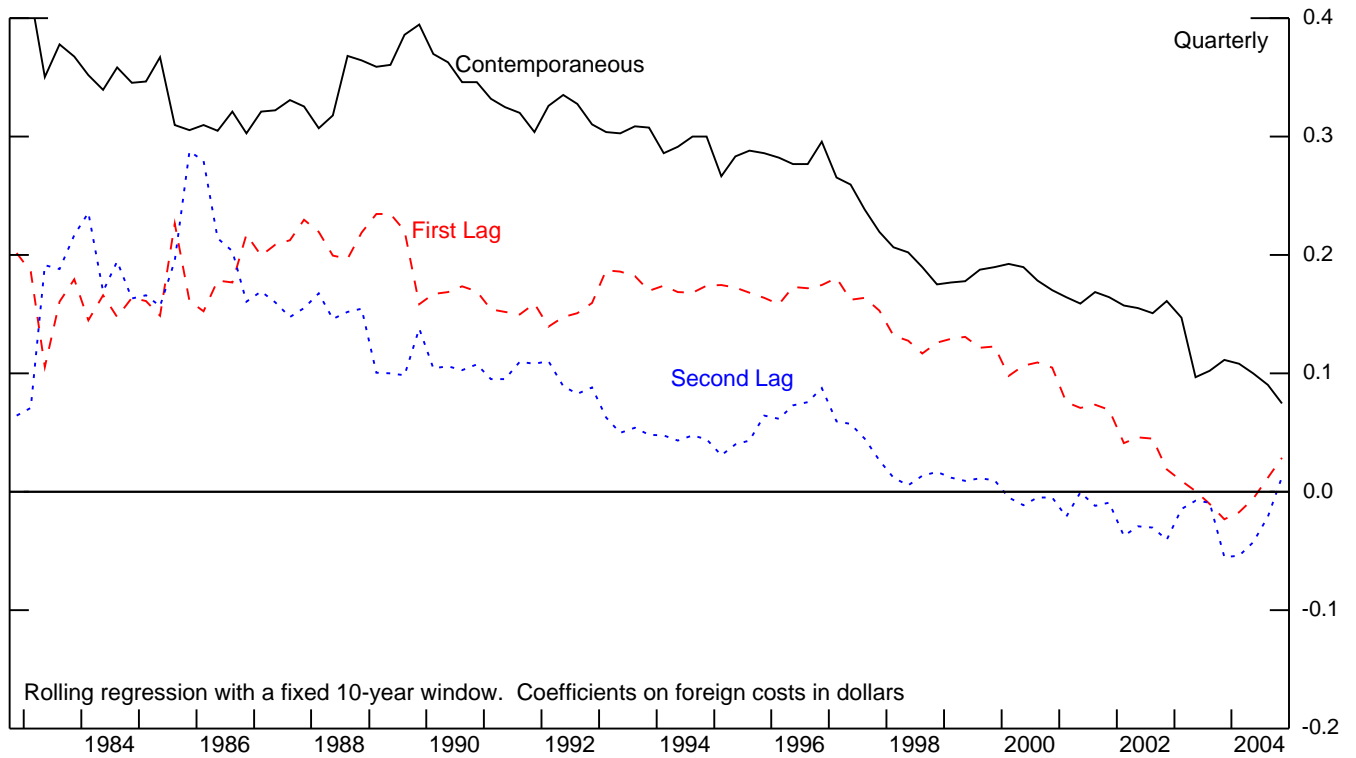


Figure 4

Evolution of Lag Structure in Exchange Rate Pass-through

With Two Lags (as in benchmark results in Figure 1)



With Four Lags

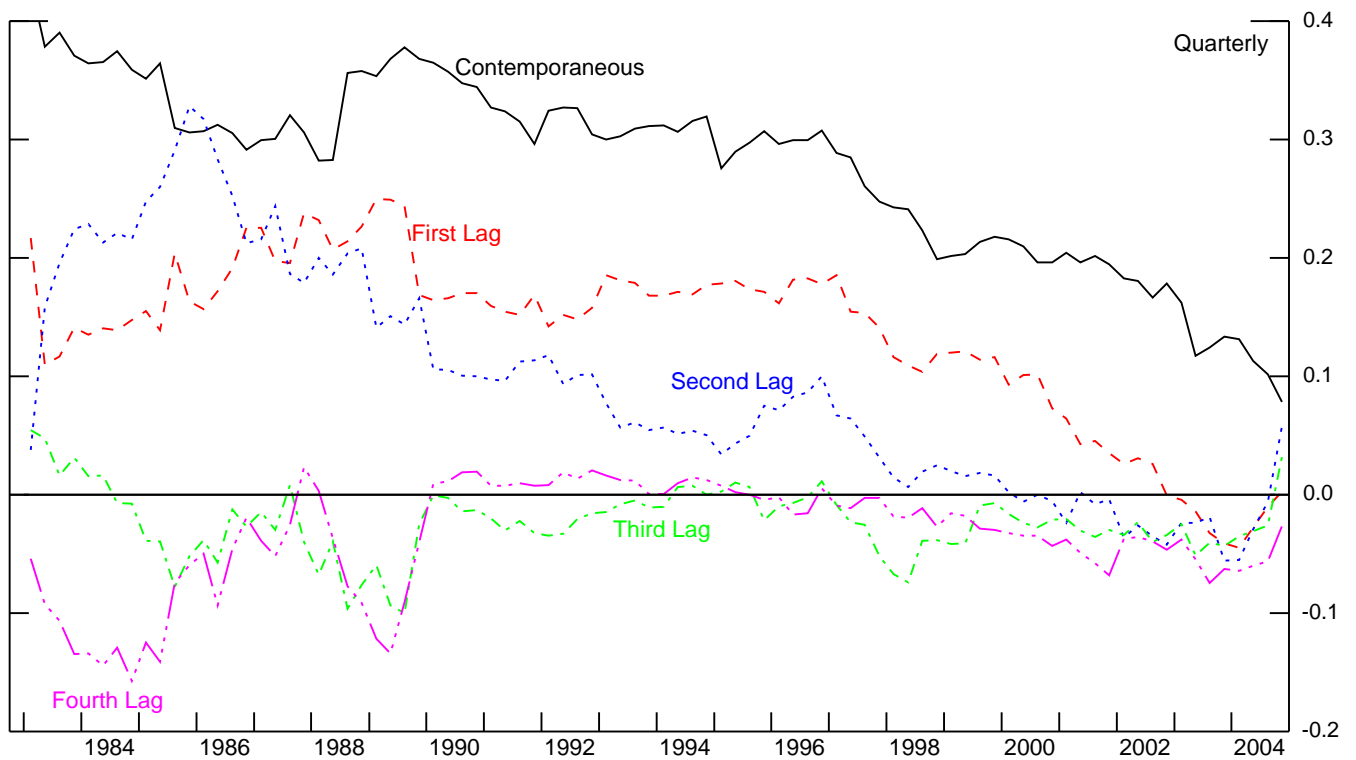
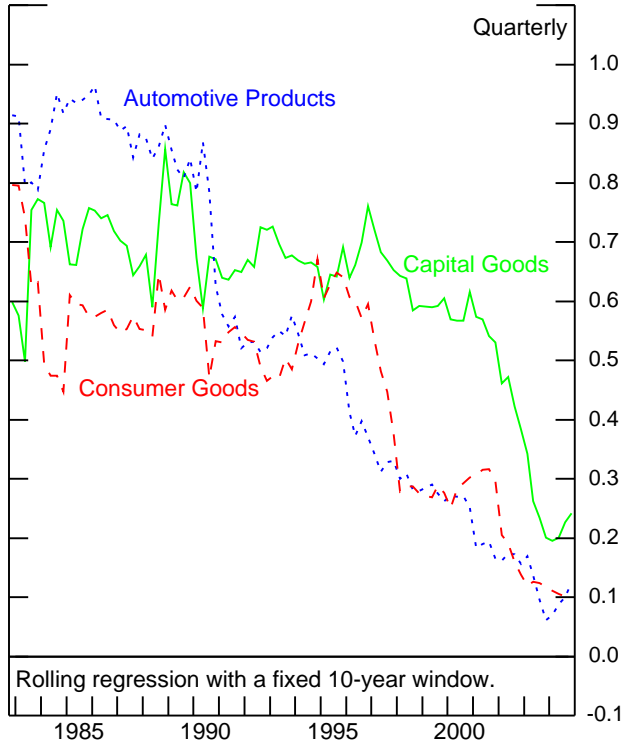


Figure 5

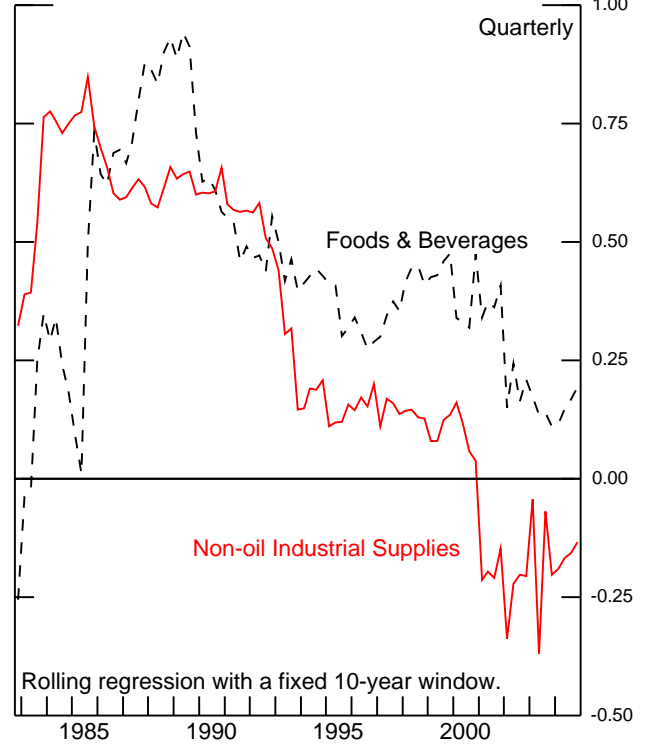
Pass-through by Type of Good

Controlling for Commodity Prices

Finished Goods

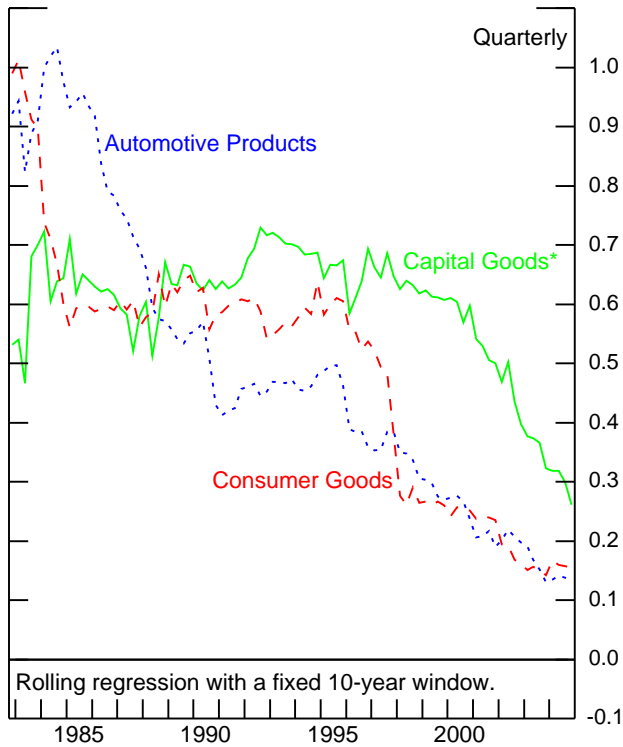


Material Intensive Goods



Without Controls for Commodity Prices

Finished Goods



Material Intensive Goods

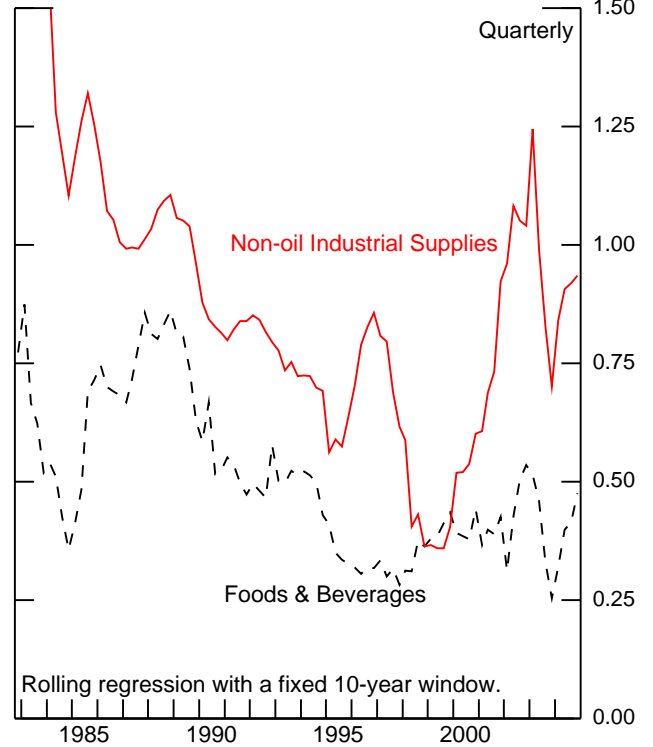
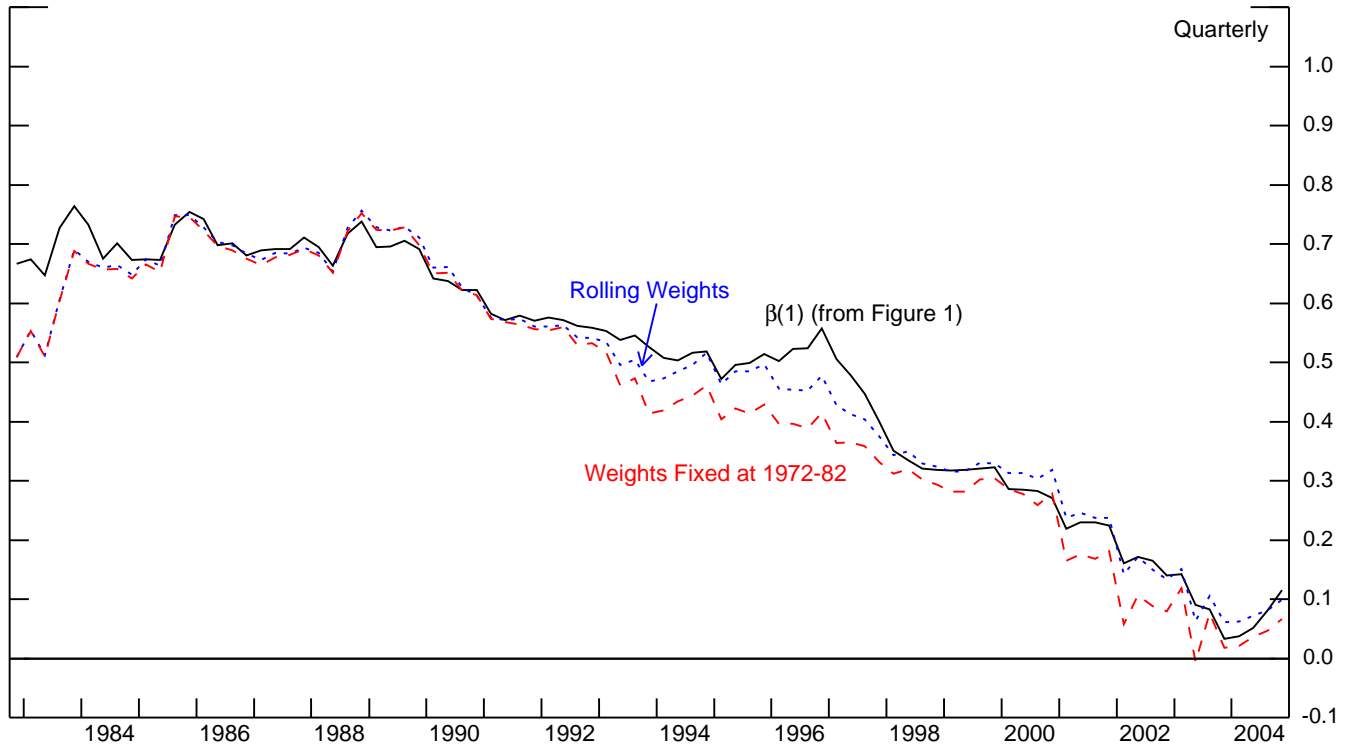


Figure 6

Weighted Estimates of Pass-through by Type of Good

Controlling for Commodity Prices



Without Controls for Commodity Prices

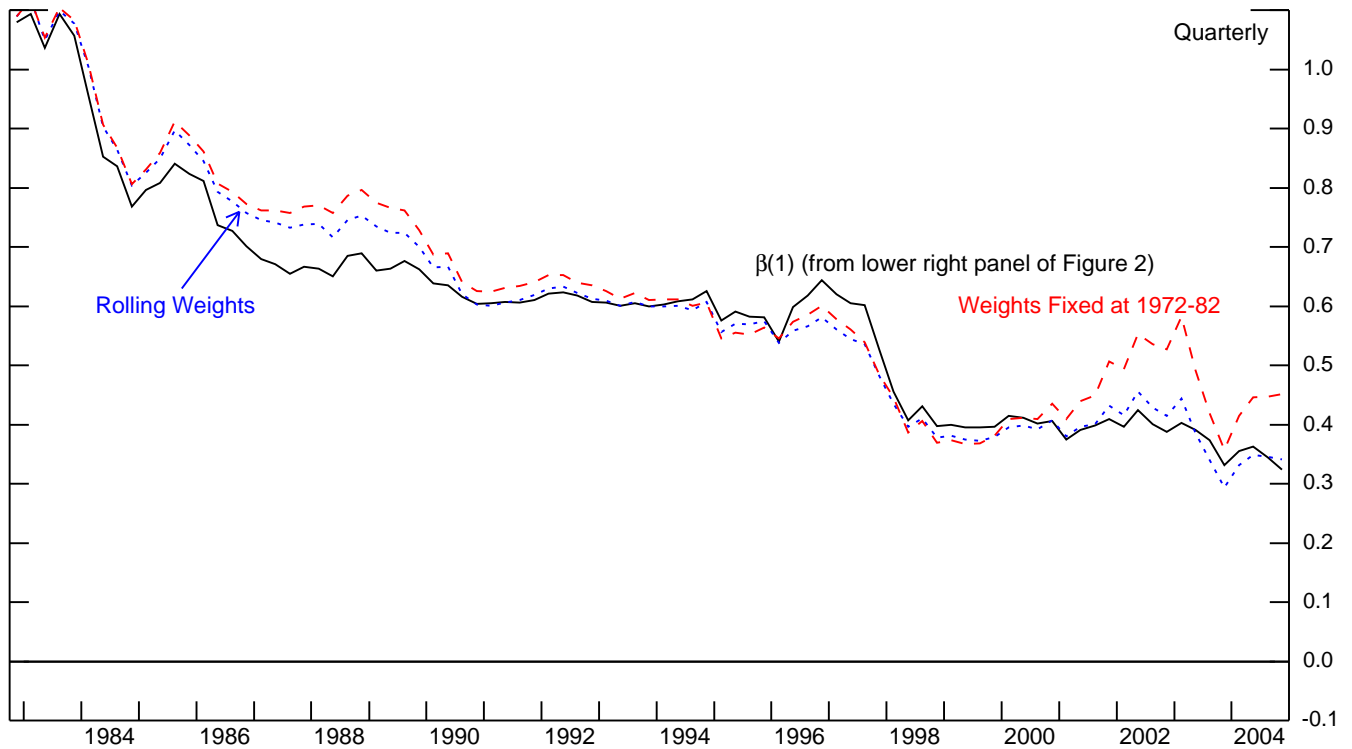


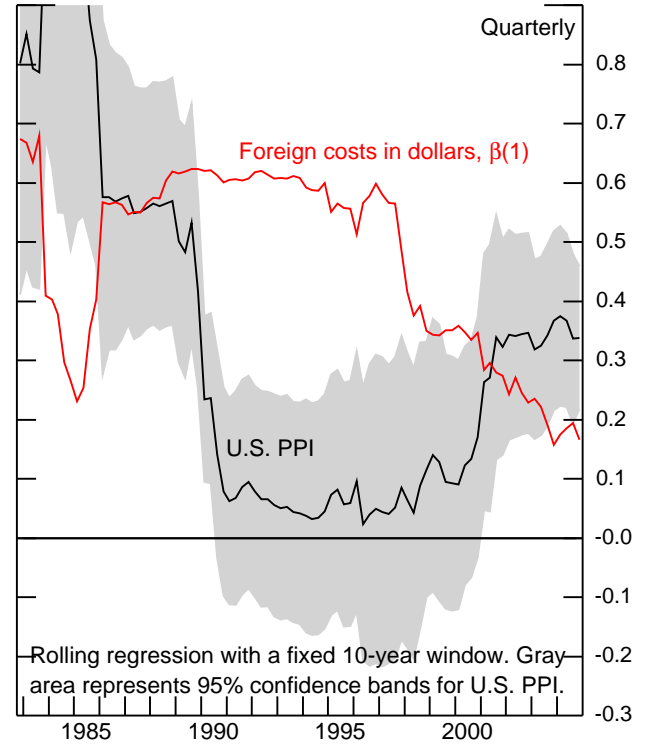
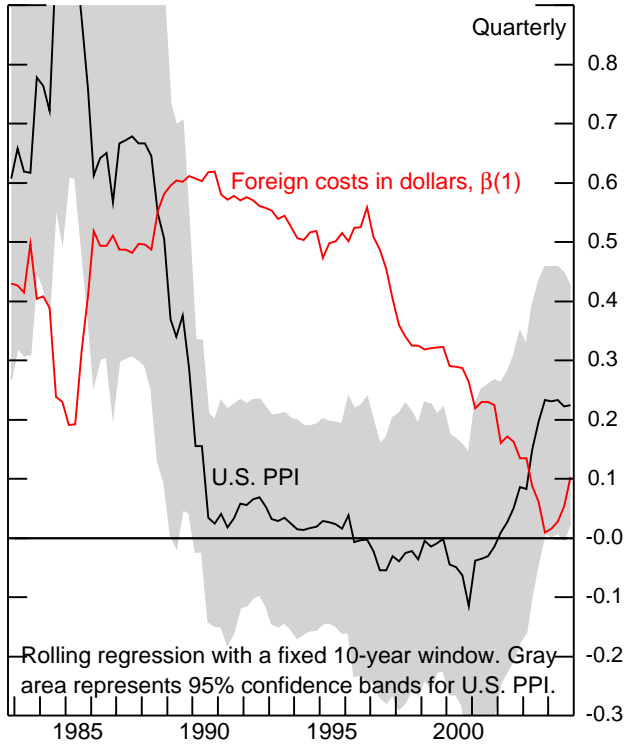
Figure 7

Are Import Prices Increasingly Driven by Domestic Prices?

Without Homogeneity Restriction

Controlling for Commodity Prices

Without Controls for Commodity Prices



With Homogeneity Restriction

Controlling for Commodity Prices

Without Controls for Commodity Prices

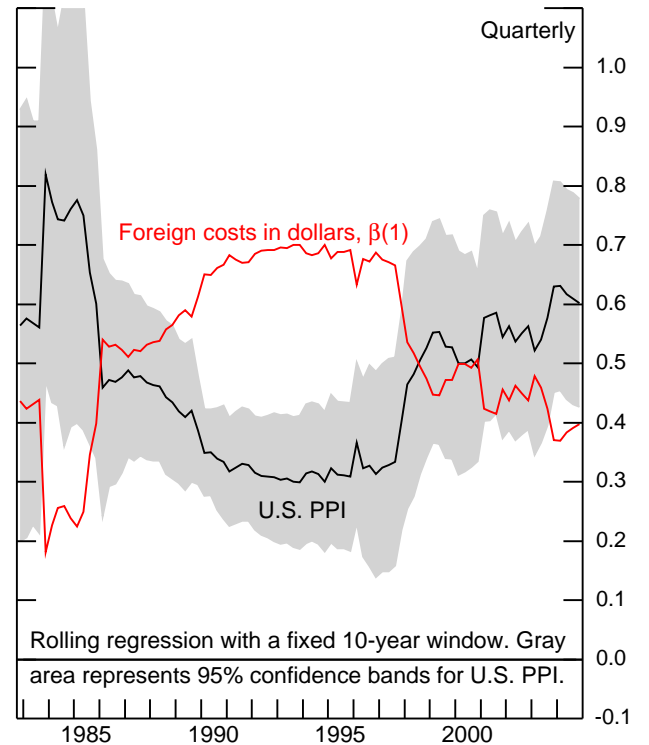
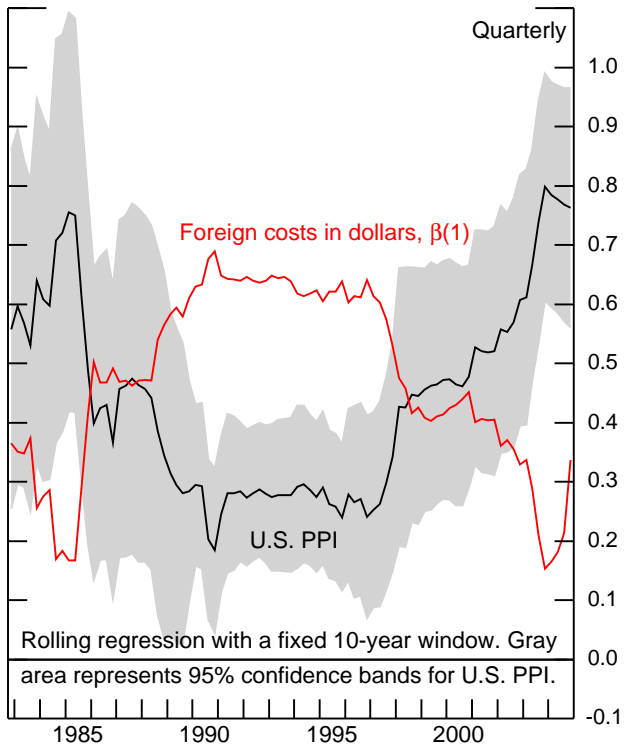


Figure 8

Pass-through and U.S. Non-oil Imports from China

Change in Pass-through Coefficient (1985-1994 vs. 1995-2004)

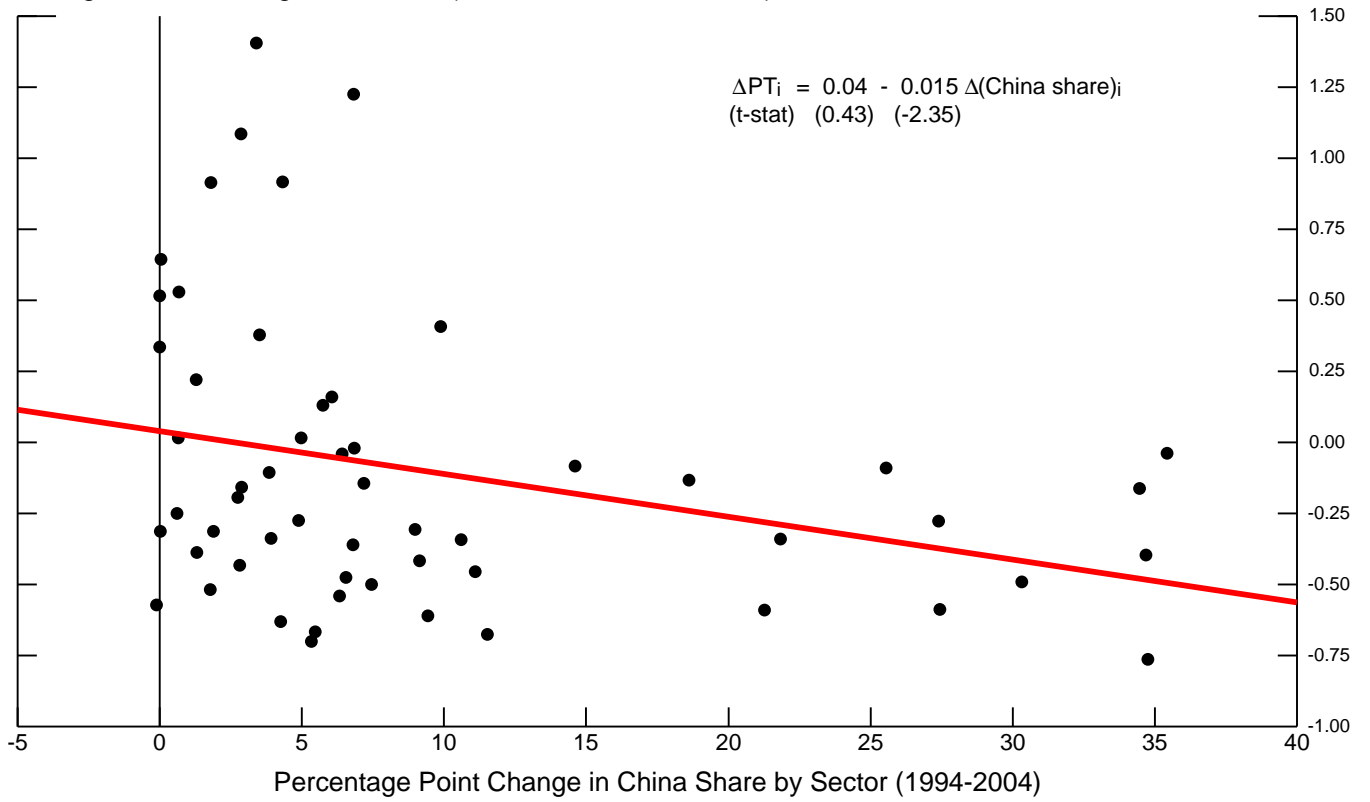


Table 1: Benchmark Results

| | <u>1972:Q4 - 1984:Q4</u> | <u>1985:Q1 - 1994:Q4</u> | <u>1995:Q1 - 2004:Q4</u> | Full Sample <u>1972:Q4 - 2004:Q4</u> |
|---|--------------------------|--------------------------|--------------------------|--|
| | (1) | (2) | (3) | (4) |
| Foreign costs in dollars, $\beta(1)$ | 0.72*** (4.66) | 0.52*** (9.64) | 0.12 (1.42) | 0.65*** (9.23) |
| Commodity Prices, $\gamma(1)$ | 0.19** (2.15) | 0.11*** (3.69) | 0.16*** (3.69) | 0.18*** (5.56) |
| R ² | 0.74 | 0.89 | 0.77 | 0.62 |
| # of observations | 49 | 40 | 40 | 129 |

Note: *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively. T-stats in parenthesis.

Table 2: Bilateral Pass-through to Import Prices of All Goods

| | <u>Specification 1</u> | | <u>Specification 2</u> | |
|----------------------------|---|---|---|---|
| | Foreign CPI in U.S. Dollars, $\beta(1)$ (1) | Commodity Prices, $\gamma(1)$ (2) | Foreign CPI in U.S. Dollars, $\beta(1)$ (3) | Commodity Prices, $\gamma(1)$ (4) |
| 1. European Union | 0.23*** (6.56) | 0.11*** (2.59) | 0.30*** (8.65) | --- |
| 2. Japan | 0.22*** (7.51) | 0.09** (2.13) | 0.22*** (8.96) | --- |
| 3. Canada | 0.03 (0.29) | 0.40*** (6.21) | 0.34*** (2.82) | --- |
| 4. Asian NIEs ⁺ | 0.21*** (5.29) | 0.10*** (2.84) | 0.23*** (6.43) | --- |

Note: The exchange rate variable is the nominal bilateral rate against the U.S. dollar. Estimation Period: 1991:Q2 - 2004:Q4. *, **, and *** indicate significance at the 10, 5, and 1 percent levels, respectively. T-stats in parenthesis. Specification 1 controls for commodity prices, including oil.

+ Includes Hong Kong, Korea, Singapore, and Taiwan.