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Abstract

Border prices of traded goods are highly sensitive to exchange rates, but the CPI, and the retail prices of these goods, are more stable. Our paper decomposes the sources of this stability for twenty-one OECD countries, focusing on the important roles of distribution margins and imported inputs in transmitting exchange rate fluctuations into consumption prices. We provide rich cross-country and cross-industry details on distribution margins and their sensitivity to exchange rates, imported inputs used in different categories of consumption goods, and weights in consumption of nontradables, home tradables and imported goods. While distribution margins damp the sensitivity of consumption prices of tradable goods to exchange rates, they also lead to enhanced pass-through when nontraded goods prices are sensitive to exchange rates. Such price sensitivity arises because imported inputs are used in production of home nontradables. Calibration exercises show that, at under 5%, the United States has the lowest expected CPI sensitivity to exchange rates of all countries examined. On average, calibrated exchange rate pass-through into CPIs is expected to be closer to 15%.

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I. Introduction

An unexpectedly small degree of consumer price index (CPI) responsiveness to import price and exchange rate fluctuations has been posed as a puzzle in empirical international macroeconomics. Researchers have argued that this gap may be explained in a competitive setting partly by the presence of nontradable goods in consumption and partly by the existence of a distribution sector which reduces the foreign content within imports, driving a wedge between border and retail prices (Burstein, Neves, and Rebelo 2003).[1] Expenditures on transportation, storage, finance, insurance, wholesaling, and retailing add local-value-added components to the final consumption value of imports and reduce the weight on border prices for imports per se in consumer price indices. An alternative explanation arises from the presence of imperfect competition in the distribution sector. Double marginalization occurs when distributors absorb some of the exchange-rate fluctuations in order to maintain stable prices or expand market share at the retail level (Hellerstein 2004). Thus, distributor profit margins also can provide partial insulation from internationally transmitted shocks. A complementary explanation, offered by Bacchetta and van Wincoop (2003), is that consumer price insensitivity to exchange rates may be generated as an optimal pass-through strategy in a model of foreign exporting firms selling intermediate goods to domestic producers who compete with nontraded goods producers.[2] Regardless of the sensitivity of border prices to exchange rates, if retailers absorb exchange rate fluctuations in their own margins, then

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[1] Campa and Goldberg (2005) and Campa, Goldberg, and Gonzalez-Minguez (forthcoming 2006) detail the pass-through rates on import prices of OECD and euro-area countries. Frankel, Parsley, and Wei (2004) also document pass-through elasticities for developing countries.

[2] Corsetti and Dedola (2005) make related arguments in a different production chain and pricing set-up.

consumers will experience less pass-through than prices at the border (Devereux, Engel, and Tille 1999, and Devereux and Engel 2002).

We explore the phenomenon of low CPI responsiveness to exchange rates by carefully framing what CPI sensitivity to exchange rates is expected to be, given the existence of home and foreign tradable goods and nontradable goods in consumption, and given the potential roles of distribution margins and imported inputs to production. These features are important for proper identification of the foreign versus local components exposed most extensively to exchange rate movements. We frame our contribution, which is primarily empirical, within a workhorse two country model with wage stickiness. Methodologically, we introduce a straight-forward variant of Obstfeld and Rogoff (2000), Corsetti and Dedola (2003), and Burstein, Neves, and Rebelo (2003). We explicitly introduce distribution margins, a sensitivity of these margins to exchange rates, and roles for imported inputs in the production of tradable and nontradable goods. The model provides a clear delineation of the determinants of the price elasticities of specific consumer goods and shows how these elasticities aggregate to yield CPI sensitivity. Consumer prices could be insensitive to exchange rates because a small share of the goods composing the CPI basket have exposure to exchange rate changes via tradable products, or because the competitive structure or the size and behavior of the distribution sector isolates final prices from exchange rate movements.

The real contribution of this paper is its empirical analysis, where we carefully apply these concepts to data from twenty-one OECD countries.[3] Most significantly, we document the size of the distribution sector and the degree of imported input use by country, by industry, and in some cases over time, and explore their respective roles in the pass-through disconnect. Since CPI discussions require margins applied on consumption goods per se, and not the typically lower margins on government and investment goods, we carefully separate out the margins by sources of final demand. Across this sample of countries, distribution margins on household consumption are between 30 and 50% of purchasers' prices.

These margins are dominated by wholesale and retail sector costs, with transportation and storage costs relatively low except in the case of various raw materials and mining industries. We use these data to explore the existence of double marginalization, wherein local wholesalers and retailers adjust their margins in response to exchange rate fluctuations. While our data can only give crude indications of margin adjustment, the available time-series evidence for eight countries supports the hypothesis that distribution margins are sensitive to exchange rates. Distribution margins fall when the local currency depreciates and imports become more expensive in local currency terms.

We further document the role of imported inputs across countries and across both tradable and nontradable goods production. In tradable goods production, imported inputs account for between 10 and 48% of the final price. Imported inputs are also used less extensively in the production of nontradables, ranging from 3% in the United States to 22% in Hungary.

Pulling together these empirical findings, we calibrate the sensitivity of country consumer price indices to exchange rates. Using data on the shares of imports in tradables consumption, the shares of tradables in overall consumption, the imported input use across sectors, and the distribution margins and their responsiveness, we compare calibrated sensitivities of various

[3] This evidence complements and considerably extends the evidence on Argentina and the United States provided by Burstein, Eichenbaum and Rebelo (2002).

price indices and the CPI. Not surprisingly, there is considerable cross-country heterogeneity in these predictions. It is also noteworthy that the calibrated CPI sensitivities to exchange rates are not systematically different from observed CPI sensitivity to exchange rates. It is not unusual for this sensitivity to be low, often below 10% of any exchange rate change.

We emphasize that the rates of exchange rate pass-through into CPIs depend on the role that tradable goods have in the economy – both tradables in consumption, and imported inputs in production of nontraded and home tradable goods. We provide substantial empirical evidence showing the extent to which distribution margins are important for damping border price pass-through into consumption prices, as stressed in recent theoretical contributions to this literature. We also emphasize, however, that the existence of these margins is an added conduit for exchange rate effects. Distribution expenditures for all tradable goods consumed are sensitive to exchange rates to the extent that the nontradable sector relies on imported productive inputs. Imported inputs matter both for the prices of directly consumed nontradable goods and for tradable goods in the final consumption baskets of most developed economies.

Section II begins our exposition by documenting the extent of the pass-through of exchange rates into import price and CPI across countries. We then present a model of pass-through into respective price indices, accounting for the roles of distribution and imported inputs. Section III presents evidence on distribution margins, imported inputs, and relevant trade shares across countries, industries, and time. Section IV generates predicted values for pass-through into the alternative price series of each country, and compares predicted and observed pass-through. Section V concludes.

II. Price Elasticities with Respect to Exchange Rates

Table 1 reports estimated pass-through rates into import prices and consumer price indexes for twenty-three OECD countries. The reported coefficients are the estimated pass-through rates from a regression of changes in import prices and consumer prices on changes in nominal exchange rates and foreign prices using quarterly data for the period 1975:1 to 2003:4. The reported estimates of pass-through of exchange rate changes are the cumulative one-year impact from an exchange rate shock estimated from a partial-adjustment model. The effects on import prices are provided in the first data column. The next data column presents similar pass-through elasticities for consumer price indices.[4] The differences between the import price and the CPI responsiveness to exchange rate movements across almost all OECD countries are striking. Pass-through into border prices far exceeds pass-through into the CPI. While striking, these differences in sensitivity are not necessarily surprising, motivating the extensive analysis of our paper.

[4] The estimation technique is based on Campa and Goldberg (2005) and provided in the technical appendix. This analysis is based on linear regression models, without cointegrating relationships modeled. See related discussion in the aforementioned paper, and in Campa, Goldberg, and Gonzalez (2006). VAR estimates are presented in the Appendix, and verify the reported results.

Table 1: Exchange Rate Pass-through Elasticities into Import and Consumer Price Indices

Country	Pass-through on Import Prices	Pass-through on Consumer Prices
Australia	0.67*+	0.09+
Austria	0.10	-0.09
Belgium	0.68	0.08+
Canada	0.65*+	-0.01+
Czech Republic	0.6*	0.60*+
Denmark	0.82*	0.16*+
Finland	0.77	-0.02+
France	0.98*	0.48*+
Germany	0.80*	0.07+
Hungary	0.78*	0.42*+
Ireland	0.06	0.08+
Italy	0.35+	0.03+
Japan	1.13*	0.11*+
Netherlands	0.84*	0.38*+
New Zealand	0.22+	-0.10*+
Norway	0.63*	0.08+
Poland	0.78*	0.59*+
Portugal	1.08*	0.60*+
Spain	0.70*	0.36*+
Sweden	0.38*+	-0.11+
Switzerland	0.93*	0.17*+
United Kingdom	0.46*+	-0.11+
United States	0.42*+	0.01+
Average	0.64	0.17

* (+) indicates exchange rate pass-through significantly different from zero (one) at a 5% confidence level. Most data are quarterly, spanning 1975 through early 2003. Data sources: nominal exchange rate and consumer prices come from the IFS; import price comes from the OECD. Specific start and end dates by country are detailed in the data appendix. Long-run elasticities (four quarters) shown.

For these OECD countries, the (unweighted) average pass-through elasticity is 0.64 for import prices. For seventeen of the twenty-three countries presented in the Table, exchange rate pass-through into import prices is statistically different from zero. This finding rejects the hypothesis that import prices in domestic currency do not adjust to exchange rate changes. Campa and Goldberg (2005) came to similar conclusions for both short-run and long-run pass-through rates in the OECD countries, as did Campa, Goldberg, and González-Minguez (2006) for the euro-area countries. Typically, most of the pass-through of exchange rates into import prices occurs within one or two quarters after an exchange rate movement.[5]

[5] The regressions over full sample data for Belgium and France, starting in 1975, support long-run pass-through elasticities in excess of one. These elasticities implausibly imply that pass-through is more than complete, instead of bounded by one. Both Belgium and France experience similar share and persistent accelerations in import prices between 1979 and 1985, with import prices more than doubling in this period. Currency depreciations during this period were not strongly trending, and were mild. If the estimation interval instead begins with 1987 data, the estimated pass-through rates for France are similar to those for the rest of Europe. Pass-through rates for Belgium decline significantly, but remain high. Due to a short available data sample we preclude Greece from this table.

By contrast, average pass-through into consumer prices is 0.17 over the long run, with much larger standard deviations. These averages mask huge cross-country differences in CPI sensitivity. Nevertheless, the hypothesis that the pass-through to CPIs is smaller than one can be rejected for all but one country, Austria, and in Austria's case the insignificant point estimate is negative. In general, larger countries tend to have lower levels of estimated pass-through into the CPI during this period, often below 10%, while estimated elasticities for some countries can be as large as 60% (Czech Republic, Poland, and Portugal).[6] The differences between the estimated import price and CPI sensitivities are large, positive, and vary extensively across countries.

A. A Two-Country Model of the Exchange Rate Pass-through

To formalize the exchange rate disconnect we use a workhorse two-country model with wage stickiness, as in Obstfeld and Rogoff (2000) and Corsetti and Dedola (2003). This approach has a utility-based framework that explicitly tracks the degree of substitutability of imported and domestic products, and presents the explicit cost functions faced by producers. We assume C.E.S. utility functions over nontraded and traded goods consumption. Both sectors produce a continuum of varieties with similar elasticities of substitution, θ. Home (h) and foreign (f) tradable goods consumption are imperfect substitutes, with an elasticity of substitution of $\phi_T > 1$. Consumption of tradable (T) and nontradable (N) products are also governed by a constant elasticity of substitution ϕ.

Given the C.E.S. structure of demand, and under the standard assumption that each variety is sufficiently small so that changes in the prices of one variety have no impact on the price aggregators, only competition among brands matters. The first-order condition faced by a producer of a brand *h* is:

$$p_t(h) = \frac{\theta}{\theta - 1} c_t(h) \tag{1}$$

where $c_t(h)$ is the marginal cost of production and delivery to consumers of brand *h*. The marginal cost of production at the producer level is determined by relative productivity levels and nominal wages, which are assumed to be fixed in the short run and exogenous to exchange rate changes. This specification implies that producer currency prices have a constant markup of prices over marginal costs.

On the supply side, the marginal cost of production includes two components of cost: the cost of producing the good and the cost of delivery of each brand to the consumer. Following Erceg and Levin (1995), Burstein, Neves and Rebelo (2003), and Corsetti and Dedola (2003), we assume that bringing one unit of traded goods to consumers requires units of a basket of

[6] Frankel, Parsley and Wei (2004) provide an extensive analysis of pass-through around the world, importantly including the developing countries, but for a smaller group of products than covered by the import price aggregates of these industrialized countries.

differentiated nontraded goods indexed by *n*.[7] For computational simplicity, no distinction is made in these models between nontradable consumption goods which directly enter an agent's utility, and nontraded distribution services which are jointly consumed with traded products. In empirical analyses, distribution costs include expenditures on wholesale and retail sector services, as well as expenditures on transportation and storage.

Let $\bar{P}_t(h)$ denote the price of brand *h* at producer level. With a competitive distribution sector, the consumer price of good *h* is simply

$$P_t(h) = \bar{P}_t(h) + m_t(h) P_t(n) \tag{2}$$

where $P_t(n)$ is the corresponding utility-based price index for nontradable products and $m_t(h)$ are the distribution service inputs required per unit of output. This specification attributes the failure of purchasing power parity across countries, at least in part, to the presence of local transaction and distribution costs, as argued by Obstfeld and Rogoff (2000). Distribution margins are direct contributors to purchaser prices $P_t(h)$. Analogous notation is used for the imported goods sector, indexed by brand *f*.

We introduce two simple extensions to this workhorse model to generate additional realism in price sensitivity to exchange rates. First, we allow for the use of imported productive inputs, thereby introducing a direct channel through which exchange rate changes influence producer marginal costs[8]. We suppose that per unit production requires imported input share $\mu_t(h)$ on home tradable goods and $\mu_t(n)$ on home nontradable goods. The pricing equations for home nontradable goods *n*, home tradable goods *h*, and imported consumption goods *f* are given by

$$P_t(n) = \frac{\theta}{\theta-1} c_t(n) = \frac{\theta}{\theta-1}\left[\frac{W_t}{Z_N} + \mu_t(n:e)\frac{eW_t{}^*}{Z_F}\right] \tag{3}$$

$$P_t(h) = \frac{\theta}{\theta-1} c_t(h) = \frac{\theta}{\theta-1}\left[\frac{W_t}{Z_H} + m_t(h:e)\cdot P_t(n) + \mu_t(h:e)\frac{eW^*}{Z_F}\right] \tag{4}$$

$$P_t(f) = \frac{\theta}{\theta-1} e_t c_t{}^*(f) = \frac{\theta}{\theta-1}\left[\frac{eW_t^*}{Z_F} + m_t(f:e)\cdot P_t(n)\right] \tag{5}$$

where W_t refers to the wage per unit of labor at home, $W_t{}^*$ refers to foreign wages, and the Z terms refer to productivity in home tradables (*h*), home nontradables (*n*), and foreign tradables (*f*). This derivation assumes that all distribution costs are incurred in the home market,

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[7] It is assumed that $m = \left[\int_0^1 m(n)^{\frac{\theta-1}{\theta}} dn\right]^{\frac{\theta}{\theta-1}}$. All traded goods use the same distribution inputs, so that sectoral differences in distribution margins are not explicitly modeled.

[8] The assumed short-run rigidity of wages to real exchange rates is supported by recent empirical analyses [Campa and Goldberg 2002, Goldberg and Tracy 2003], except perhaps for some of the less-skilled workers changing jobs. Some sectoral differences in wage elasticities are evident in U.S. data.

and productivity parameters as well as domestic and foreign wages are sticky over the relevant pricing horizon. *e*, the exchange rate, is the domestic currency price of foreign exchange.[9]

This widely used basic framework assumes sticky wages, exogenous productivity, and a monopolistic competition set-up that generates the mark-up rule over costs noted above. The idea of local content in the final consumption of imported goods is found in various forms elsewhere. Most explicitly, terms like $m_t \cdot P_t(n)$ are found in Corsetti and Dedola (2003) and Burstein, Neves and Rebelo (2003), where distribution costs drive a wedge between border and consumption prices on imports. Other studies consider imports more as intermediate goods that are re-priced or combined with local content by distributors (or home final goods producers). Devereux, Engel, and Tille (1999) and Devereux and Engel (2002) gave the distributor power to re-price imported goods, resulting in imported goods prices that were sticky in the consumer's currency and consistent with prevalent local currency pricing. Obstfeld and Rogoff (2000) had final consumption goods generated when traded goods were treated as intermediate goods, without re-pricing, so that producer currency pricing was more prevalent. Bacchetta and van Wincoop's (2003) model enables distributors to choose a pricing structure that minimizes relative price fluctuations on the imported good. By contrast, Burstein, Neves, and Rebelo (2003), following Erceg and Levin (1945), implicitly assume perfect competition among distributors, who cannot therefore adjust the size of margins charged to deliver each brand to the consumer. Under this assumption, the distribution sector drives a wedge between border price and consumption price sensitivity to exchange rates, but does not have a role beyond being an input into final consumption.

In our specification of distribution costs in equations (4) and (5) we introduce the exchange rate as an argument of the distributor margin $m_t(i:e)$, where $i \in (h, f)$. Including this relationship allows for possible deviations in the empirical analysis from the competitive distribution sector assumed in equation (2) above. Our specification doesn't take a stand on a particular industrial or competitive structure, and instead is intended to be general enough to permit a fixed distribution margin in the face of currency fluctuations or to permit large margin responses if particular assumptions on industrial structure would warrant this. The process by which distributors attempt to actively manage consumer prices is referred to as "double marginalization," as in Hellerstein (2004).

A second modification we make to the standard approach is the existence of imported inputs, as well as home inputs, into the cost of producing home tradable goods. These imported input shares, $\mu_t(i:e)$, $i \in (n,h)$, vary by type of goods, and can be sensitive to exchange rate movements. This sensitivity could subsume the effects of domestic agents re-pricing imported intermediates for local markets and perhaps adding a bit of local content.

We differentiate equations (3) through (5) to derive home tradable, home nontradable, and imported goods price elasticities, or pass-through rates, with respect to exchange rates.

[9] This specification, which follows Corsetti and Dedola, implies that the markup on the final price is also charged by the producer on the distribution part of the costs. An alternative approach could delink the markups on the producer and distribution costs. Our derivation disregards the second-order effect of nontradables sector use of imported inputs in the costs of the home tradables and in the distribution costs of the imported goods.

$$\eta^{P(n),e}=\frac{\partial P(n)/\partial e}{P(n)/e}=\left(1+\eta^{u_t(n:e),e}\right)\left[\frac{\mu_t(n:e)\frac{ew^*}{Z_F}}{c_t(n)}\right]=\frac{\theta}{\theta-1}\left(1+\eta^{u_t(n:e),e}\right)\left[\frac{\mu_t(n:e)\frac{ew^*}{Z_F}}{P_t(n)}\right] \quad (6)$$

$$\eta^{P(h),e}=\frac{\partial P(h)/\partial e}{P(h)/e}=\frac{\theta}{\theta-1}\left[\left(\eta^{P(n),e}+\eta^{m(h),e}\right)\frac{m(H:e)P(n)}{P_t(h)}+\left(1+\eta^{u_t(h:e),e_t}\right)\frac{\mu(h:e)\frac{eW^*}{Z_F}}{P_t(h)}\right] \quad (7)$$

$$\eta^{P(f),e}=\frac{\partial P(f)/\partial e}{P(f)/e}=1-\frac{\theta}{\theta-1}\frac{\left(m(f:e)P_t(n)\right)}{P(f)}\left[1-\left(\eta^{m(f),e}+\eta^{P(n),e}\right)\right] \quad (8)$$

In equation (6), which assumes monopolistic competition, the necessary condition for nontraded goods prices to be sensitive to exchange rates is that producers use imported inputs. Exchange rate changes pass-through fully into the costs of imported inputs, except to the extent that the production structure allows substitution away from these inputs when they are more expensive, $\eta^{\mu_t(n:e),e}<0$.

Equation (7) shows that home tradables prices can respond to exchange rates through two channels: imported inputs in production, or distribution margin responses to exchange rate movements. Distribution expenditures can vary both because nontradables prices can respond to exchange rates and because distributors may actively, and perhaps strategically, adjust their markups on home tradables when the prices of competing imported brands move with exchange rates. Exchange rate changes fully pass-through into imported input costs, putting upward pressure on final prices except to the extent that the home tradables producers can substitute away from the imported inputs.

Equation (8) is typically the focal point of studies of the sensitivity of foreign goods prices to exchange rates. Note, however, that this specification gives not border price sensitivity but, rather, consumption price sensitivity to exchange rates. Under monopolistic competition, pass-through into border prices will be complete, except in the presence of a distribution sector. The distribution sector damps the import content of this consumption good (the first term), with the magnitude of this damping dependent on whether distributor markups and nontraded goods prices respond to exchange rates.

The price elasticity also is smaller when elasticities of substitution among goods θ are larger: producers charge a smaller markup over costs when the competitive environment is more intense. As in Corsetti and Dedola (2003), productivity conditions play an important role in determining exchange rate pass-through, leading to a “state contingent component of markups”, whereby the prices charged by a producer in different markets depend on asymmetries across countries in relative productivity and wages. The higher the productivity in home tradable goods production relative to home nontradables, the larger the pass-through.

We have not assumed a specific functional form for the elasticity of response of distribution expenditures on home tradables and imported goods with respect to exchange rates. Presumably, when the prices of imported goods rise, domestic distributor profits expand and the sale price on competing domestic tradable goods may also rise incrementally. Pass-through of exchange rate fluctuations into import prices should be dampened when local distributor margins can adjust in response to domestic currency depreciation. While we have not explicitly modeled the elasticity of distributor margins, more structure on this can certainly be imposed. For example, one could take advantage of differences when exchange rate fluctuations are viewed as transitory versus permanent, an intuition early expounded by Froot and Klemperer (1989).

B. Pass-through into Import Prices Relative to Consumer Prices

To derive the gap between import price and CPI responsiveness to exchange rates, we begin with a CES aggregator $P_t = \left[\alpha P(T)_t^{1-\phi} + (1-\alpha)P(n)_t^{1-\phi}\right]^{\frac{1}{1-\phi}}$, where $P_t(T)$ and P_t(n) are price aggregators for tradable and nontradable products respectively, ϕ is the substitution elasticity and α is the consumption weight. Pass-through of exchange rates into the aggregate CPI is given by

$$\eta^{P,e} = \alpha\left(\frac{P_t(T)}{P_t}\right)^{1-\phi}\eta^{P(T),e} + (1-\alpha)\left(\frac{P_t(n)}{P_t}\right)^{1-\phi}\eta^{P(n),e} \tag{9}$$

Prices of tradable goods are subject to a similar aggregator, where ϕ_T is the substitution elasticity and α_T is the consumption weight. Expanding this expression using the tradable goods aggregator, the CPI elasticity with respect to exchange rates is

$$\eta^{P,e} = \alpha\left(\frac{P_T}{P}\right)^{1-\phi}\alpha_T\left(\frac{P_H}{P_T}\right)^{1-\phi_T}\eta^{P_H e} + \alpha\left(\frac{P_T}{P}\right)^{1-\phi}(1-\alpha_T)\left(\frac{P_F}{P_T}\right)^{1-\phi_T}\eta^{P_F e} + (1-\alpha)\left(\frac{P_N}{P}\right)^{1-\phi}\eta^{P_N e} \tag{10}$$

Aggregate CPI pass-through is a weighted average of pass-through elasticities into traded and nontraded prices. These two elasticities are state-contingent and dependent on relative wage and productivity parameters in domestic and foreign markets (i.e. unit labor costs), elasticities of substitution observed between tradable (foreign and domestic) and nontradable goods, imported input use in domestic production, and distribution margins. The CPI elasticity also depends on the share of tradables in consumption, the share of imported goods in tradables, and substitution elasticities between products. A higher α magnifies the role of $\eta^{p(h),e}$ and $\eta^{p(f),e}$. A higher α_T expands the role of $\eta^{p_h,e}$ at the expense of $\eta^{p_f,e}$. State-dependent elasticity is introduced by initial relative prices of different types of goods in the economy and by the related comparisons of unit labor costs across different types of goods.

When $\phi = \phi_T$, equation (8) becomes

$$\eta^{P,e} = \alpha\cdot\alpha_T\left(\frac{P(h)}{P}\right)^{1-\phi}\eta^{P(h),e} + \alpha\cdot(1-\alpha_T)\left(\frac{P(f)}{P}\right)^{1-\phi}\eta^{P(f),e} + (1-\alpha)\left(\frac{P(n)}{P}\right)^{1-\phi}\eta^{P(n),e} \tag{10}$$

Rule-of-thumb discussions sometimes incorrectly think of the import share in domestic demand as the main transmission channel for exchange rates into aggregate price indices. If the home tradables share in consumption is zero, such a rule of thumb would focus attention on the second term of equation (10). However, there are clearly other forces at work that imply different responses of consumption goods to exchange rates. To some degree, basic pass-through depends on price elasticities, consumption shares, distribution margins, and imported input use. Adjustments to this basic measure come about because elasticities of distribution expenditures and imported inputs vary with exchange rates.

Because nontraded goods are consumed directly and provide local content into both home tradable goods and imported goods, this channel can be particularly important for the CPI sensitivity to exchange rates in this model. This channel disappears only if exchange rate movements trigger full substitution away from imported inputs (or if imported input costs are insensitive to exchange rates, as they are when priced in local currency). Exchange rates affect home tradables prices due to the use of imported inputs in the production of these goods. Again, only fully inelastic input costs would make this channel insignificant.

Other channels may impact the CPI through imported goods. There is direct transmission into the CPI through the foreign content of the consumption good indexed by f, that is, all of the value of this consumption good less the expenditure on distribution costs. The only modification to this channel occurs if the expenditure on distribution changes when the exchange rate moves. This latter adjustment is the double marginalization effect previously discussed. Finally, there also is a possibility that distributors change the margins charged on home tradable goods when they observe competing imports having price changes attributable to exchange rates.

III. Evidence on the Distribution Sector and on Imported Inputs in Production

As the previous derivation shows, explaining pass-through into different price measures requires data on distribution margins, demand elasticities, imported input use, consumption shares, and relative prices within countries. Among these series, the evidence on distribution margins and imported inputs in production – across industries, and across countries – are the least well documented. Burstein, Neves, and Rebelo (2003) provide evidence on the size of distribution margins using data for two countries, the United States and Argentina. They conclude that local distribution services (expenditures on transport, wholesale and retail services, marketing, etc.) account for at least half of the retail prices of consumer goods, and an even higher share of tradable agricultural products. Rauch (1999) found that transportation costs (transport and freight expenditure as a percentage of customs value) for U.S. imports from Japan, or similarly distant countries, in 1970, 1980, and 1990 ranged from 6 to 16%. Hummels (1999) estimated average trade-weighted freight costs in 1994 at 3.8% for the United States, and 7.5% for Argentina. Goldberg and Verboven (2001) concluded that local costs account for up to 35% of the price of a car.

The evidence on imported inputs is even more limited. Campa and Goldberg (1997) provide evidence for the evolution of imported inputs since 1975 into manufacturing for the U.S., Canada, Japan and the UK. Hummels, Ishii and Yi (2001) present evidence in their work on understanding the domestic content of a country's exports. Other evidence on this falls under the heading of outsourcing analysis, as exemplified by work surveyed in Feenstra and Hanson (2005).

This paper dramitically expands our empirical understanding of these two subjects. We provide evidence on distribution margins and imported inputs into production for twenty-one countries, broken down into approximately thirty industries within each country and, in some cases, captured over time. Our measures are more aggregated than the micro studies of particular goods production chains,[10] but are consistent with those findings and enable macro analysis of country-wide exchange rate pass-through into import prices and the CPI. The advantage of our measures is that they are consistently estimated across countries and have a relatively large degree of comparability. In a number of countries, we are able to differentiate between wholesale and retail distribution margins and transportation margins. For some countries, we characterize margin dynamics over time and estimate the role played by exchange rate fluctuations in these dynamics.

A. Data and Measurement Issues

We derive information to compute the measures of imported input and distribution margins from input-output tables. Three different kinds of prices are used in Input-Output analyses: basic prices, producer prices, and purchaser's (or final) prices. Basic prices are the cost of intermediate consumption plus cost of basic inputs (labor and capital) plus other net taxes linked to production. Producer prices are basic prices plus other net taxes linked to products. Purchaser or final prices are the sum of producer prices and distribution margins (retail trade plus wholesale trade plus transport costs) plus Value Added Taxes. The different tax components are twofold: "Other taxes linked to production" are those taxes (or subsidies) levied on companies due to the fact that goods are produced, but are not linked to the amount produced or sold. "Other taxes linked to products" are those taxes (or subsidies) levied on companies that are linked to the amount produced or sold. These include VAT tax on the production process, import duties, plus other taxes.

The OECD provides homogeneous input-output information for a large sample of countries. However, we chose not to use the OECD information in this paper. The OECD input-output tables often are constructed using producers' prices, and therefore contain price distortions due to country tax codes. To avoid these distortions we estimate the distribution margins as the ratio of these costs relative to the value in purchasers' prices. For this type of data, we use Eurostat tables and country source data, sometimes drawn from so-called "supply-use" tables. These tables provide symmetric input-output tables broken down by domestic production and imports. The value of each cell in the domestic (or import) table reports the amount of inputs consumed from the row industry by the column industry that are produced domestically (or abroad). We compute the imported input measure as the ratio for each industry between the total amount of imported inputs to the sum of the total amount of domestically produced and imported inputs.

We compute two types of margins. Our preferred margins are "purchasers' price margins", i.e. the expenditures on distribution margins plus transportation taken relative to total supply valued at purchasers' prices. Our "basic price margins" are similar, except that supply is valued at basic prices. The measures constructed using basic prices avoid the issue of different VAT tax rates, import duties, etc. across the different countries. The margins at purchasers' prices include net taxes on production and products. Conceptually, the basic margins are more similar to supplier calculations, while the purchasers' margins are closer to calculations on the basis of consumer prices. The literature has traditionally used margins measured relative to purchasers' prices and, for consistency, we will focus most of our discussion in this section on this measure. The original source of the information for the countries for which we compute margins and the years for which we have used country data are presented in Table 2.

[10] For example, Hellerstein (2003) and Goldberg and Verboven (2001).

Table 2: Data Sample from Input-Output Tables, by Year, Country, and Information Type

	Available years	Price Computation Method	Source
Australia	1999/2000 & 2000/2001	Supply, Use and Margins table	Australian Bureau of Statistics
Belgium	1995-2001 1995 & 2000	Supply Table Use table for imports	Eurostat
Denmark	1995-2001 1995 & 2000	Supply Table Use table for imports	Eurostat
Estonia	1997 1997	Supply Table Use table for imports	Eurostat
Finland	1995-2002 1995 & 2000	Supply Table Use table for imports	Eurostat
France	1995, 1997, 1999-2000 2000	Supply Table Use table for imports	Eurostat
Germany	1995 & 1997-2001 1995 & 2000	Supply Table Use table for imports	Eurostat
Greece	1998 1998	Supply Table Use table for imports	Eurostat
Hungary	1998-2000 2000	Supply Table Use table for imports	Eurostat
Ireland	1998 1998	Supply Table Use table for imports	Eurostat
Italy	1995-2001 1995 & 2000	Supply Table Use table for imports	Eurostat
Netherlands	1995-2001 1995-2000	Supply Table Use table for imports	Eurostat
New Zealand	1996	Supply, use, and import tables	Statistics New Zealand
Norway	2001-2002 2001-2002	Supply Table Use table for imports	Eurostat
Poland	2000 2000	Input output table Use table for imports	Eurostat
Portugal	1995-1999 1999	Supply Table Use table for imports	Eurostat
Spain	1995-2000, 1995	Supply Table Use table for imports	Eurostat
Sweden	1995-2001 1995	Supply Table Use table for imports	Eurostat
United Kingdom	1995-2001 1995	Supply Table Use table for imports	Eurostat
United States	1995-2002 1997	Annual I-O Accounts Benchmark I-O table	Bureau of Economic Analysis

In the last column of Table 2 we report the source of the data for each country. Industry classifications differ slightly by source. We compute margins for each of the original industries in each source (for example, 91 in the case of the United States), then map these to 58 industry headings (of which 29 are manufacturing and primary industries with positive distribution margins), which we treat as comparable across countries.[11] We compute overall distribution margins and also use the input-output and supply-use tables of data to decompose the margins into two component parts. For each industry and each country, one part of the margin is attributable to transportation and storage costs, and the other to wholesaler and retailer charges. The transport margins include transportation costs paid separately by the purchaser and included

[11] This harmonization and the industry definitions are not exact across countries, but we nonetheless treat these as matched in our specific empirical discussions.

in the use of products at purchasers' prices but not included in the basic prices of a manufacturers' output or in the trade margins of wholesale or retail traders. The underlying premise motivating this split is our expectation that the component of the total distribution margins associated with wholesalers and retailers are likely to be most responsive to exchange rate movements. Both margin components, however, would be important for persistent deviations in the law of one price across products and countries.

B. The Size of Country and Industry Distribution Margins

We measure distribution margins for 29 manufacturing and primary-industry groupings. The range of values for the distribution margins across countries and for these 29 industries (unweighted by country or industry size) are provided in Table 3. A number of important features of the distribution margin data are immediately apparent. First, margins vary considerably across industries. Second, there are common patterns across countries in the incidence of high and low margins for industries. Margins are consistently high in furniture and miscellaneous manufactured goods (36), as well as in wearing apparel and furs (18), tobacco products (16), and fish and fishing products (5). Margins appear to be lowest on some commodity-type products and industries, such as petroleum and natural gas (11), ores and mining products (12, 13, 14), and basic metals (27). *Margins on the order of 20% of the producer price are commonly observed across industries.*

Looking in more detail within industries, in some cases we are able to decompose the distribution margins into the share attributed to wholesalers and retailers, versus the share in transport and storage. The wholesale and retail components dominate distribution costs in almost all industry reporting data, accounting for about 90% of the total distribution costs added to the basic prices of goods. The actual size of the "trade" margin is often in excess of 20% of purchaser prices, and can be as high as 70 to 90% in some narrow product categories. The transport margins are typically less than 5% of the purchaser prices, with the exception of some of the mining and extractive resource industries. Generally, these are the only industries where we observe transportation margins dominating distribution costs.

In Table 4, we provide some of this decomposition information, and also consider the size of these distribution margins from the vantage point of countries, rather than industries. In order to construct these country margins for each country, we sum the distribution margins for all industries that report non-negative margins (the net consumers of distribution services), and divide this by the sum of output of all industries net of the output of those industries with negative distribution margins at purchaser prices. Here, and in Table 5, note that distribution margins are computed with respect to purchasers' prices, as in the form presented in equation (2) of the paper. As reported in Table 4, we calculate aggregate distribution margins on the order of 15 to 25% of output for the industries in this industrialized country sample. Expenditures on wholesale and retail services account for the vast majority of these distribution margins. While there is cross-country variability, the range of values across countries is somewhat narrow, from a low of 8.4% in Hungary and Finland to a high of 24% in the United States.

Table 3. Industry Patterns of Imported Input Use and Distribution Margin Shares

Product	Imported Inputs			Distribution Margins Total Margins		
	Average	Max.	Min.	Average	Max.	Min.
01 Products of agriculture, hunting and related services	17.25	54.47	6.33	16.40	27.52	1.67
02 Products of forestry, logging and related services	13.93	38.73	1.57	16.52	34.87	0.00
05 Fish and other fishing products; services incidental to fishing	20.33	60.64	2.74	23.72	54.43	2.42
10 Coal and lignite; peat	13.39	50.79	0.00	14.69	45.90	0.00
11 Crude petroleum and natural gas, services incidental to oil and gas extraction, excluding surveying	21.67	75.15	0.00	4.91	17.30	0.00
12+13 Uranium, thorium and metal ores	1.04	9.93	0.00	3.21	7.69	0.00
14 Other mining and quarrying products	15.67	60.08	0.00	19.40	43.20	0.00
15 Food products and beverages	21.12	48.27	5.74	19.67	29.67	8.96
16 Tobacco products	20.45	34.97	10.20	14.75	32.27	3.05
17 Textiles	31.74	55.68	0.00	20.54	38.53	7.95
18 Wearing apparel; furs	46.50	75.15	22.57	32.61	61.52	11.29
19 Leather and leather products	50.27	87.59	11.26	29.06	70.35	10.28
20 Wood and wood products	48.06	82.10	13.53	13.40	28.00	3.13
21 Pulp, paper and paper products	27.84	47.91	14.13	13.68	24.32	4.58
22 Printed matter and recorded media	41.68	77.97	16.02	15.98	26.40	7.10
23 Coke, refined petroleum products and nuclear fuel	23.62	47.42	10.52	13.53	40.54	4.67
24 Chemicals, chemical products and man-made fibers	67.28	90.92	0.00	16.80	27.30	3.46
25 Rubber and plastic products	43.56	67.96	19.90	13.61	28.01	5.14
26 Other non metallic mineral products	46.41	76.17	23.20	17.02	24.71	5.89
27 Basic metals	26.35	53.98	6.94	10.35	22.51	3.90
28 Fabricated metal products, except machinery and equipment	45.50	76.51	23.25	13.70	29.88	6.98
29 Machinery and equipment n.e.c.	34.57	76.22	17.83	14.04	31.77	4.35
30 Office machinery and computers	39.73	75.17	16.93	17.86	46.05	2.60
31 Electrical machinery and apparatus n.e.c.	56.43	98.42	34.98	12.64	24.23	2.55
32 Radio, television and communication equipment and apparatus	44.53	82.93	19.58	14.52	54.05	2.78
33 Medical, precision and optical instruments; watches and clocks	56.79	97.98	21.59	17.82	37.08	6.54
34 Motor vehicles, trailers and semi-trailers	43.08	72.86	18.82	13.45	23.15	6.40
35 Other transport equipment	50.96	83.22	16.86	6.76	26.38	1.44
36 Furniture; other manufactured goods n.e.c.	43.35	70.66	18.93	27.14	50.30	7.94

* Product names given with CPA Codes (Classification of Products by Activity). The margins represent the average of the wholesale and retail and transportation margins. Margins are calculated as: distribution margins divided by output at purchasers' or final prices. "Average Country Distribution Margins" are calculated as the sum of all non-negative distribution margins in a country's data, divided by the sum of all output from all industries (except those with negative margin numbers). Imported Input share is calculated as the average of the imported input share for each industry. "n.e.c." means not elsewhere classified. The sample included are the countries and years reported in the first two columns of Table 4.

Table 4. Share of imported inputs in total costs and share of distribution margins in purchasers' prices, by country*

Country	Reference Year	Share Imported Inputs	Share Distribution margins		
			Average	Max	Min
Australia	2000/2001	-	21.4	54.1	3.6
Austria**	2001	29.4	15.6	34.6	0.0
Belgium	2000	31.7	13.8	34.9	2.5
Denmark	2000	25.5	16.0	35.8	2.5
Estonia	1997	39.5	12.1	25.9	3.4
Finland	2002	22.9	13.2	35.5	3.1
France	2000	14.1	19.4	62.3	1.0
Germany	2000	21.4	15.1	42.4	3.6
Greece	1998	-	19.6	46.8	0.4
Hungary	2000	33.5	8.4	23.8	0.4
Ireland	1998	48.5	9.5	27.0	0.0
Italy	2000	18.5	18.4	45.2	3.7
Netherlands	2001	30.0	14.6	36.5	0.0
New Zealand	1995/1996	-	13.9	32.3	0.0
Norway	2002	22.2	16.6	4.6	3.2
Poland	2000	19.0	-	-	-
Portugal	1999	22.9	14.8	28.8	0.0
Spain	1995	17.5	18.1	75.5	0.1
Sweden	2001	26.1	15.4	35.8	1.0
United Kingdom**	2000	20.2	20.7	46.1	0.0
United States	1997	8.2	23.9	70.4	4.7

* Imported input ratios refer to the ratio of imported inputs to total inputs in all industries in each country, with the exception of the US, where they refer to manufacturing only. Margin calculations for each country are taken as the simple average of all distribution margins relative to the purchasers' prices for the 29 homogenous industries reported in Table 3. Total margins may not equal the sum of trade and transportation margins due to rounding.

** The data for imported inputs for Austria refer to 2000 and for the United Kingdom to 1995.

C. Distribution margins by component of final demand

The reported margins in the previous section refer to the distribution margins for aggregate final demand in each industry or country. However, margins differ substantially across the components of final demand. For CPI discussions, we look exclusively at margins that apply to consumption demand. To illustrate the stark differences in margins across categories of final demand, Table 5 presents comparisons of margins across household consumption, fixed capital formation, and exports. For each of these final demand categories, we report the total distribution margins and their breakdowns between transport versus wholesale and retail components.

Table 5. Distribution Margins by Source of Final Demand (Percent)

Country	Year	Household Consumption			Fixed Capital Consumption			Export		
		Wholesale-Retail	Transport	Total	Wholesale -Retail	Transport	Total	Wholesale-Retail	Transport	Total
Australia	2000/2001	-	-	-	-	-	-	-	-	-
Austria	2000	36.08	8.76	44.84	17.57	0.59	18.16	6.71	3.38	10.09
Belgium	2000	29.24	5.41	34.65	15.91	0.42	16.34	7.16	3.99	11.14
Denmark	2000	40.15	6.05	46.20	17.18	0.21	17.39	10.51	19.08	29.58
Estonia	1997	24.15	7.64	31.79	7.16	0.51	7.66	5.85	14.91	20.77
Finland	2002	41.80	8.35	50.15	3.38	0.22	3.60	0.62	3.76	4.38
France	2000	27.26	6.24	33.50	7.96	1.39	9.35	3.20	5.24	8.44
Germany	2000	33.00	7.30	40.30	5.60	2.16	7.76	5.26	4.19	9.46
Greece	1998	31.02	6.50	37.52	13.60	0.00	13.60	13.44	13.75	27.19
Hungary	2000	30.60	6.87	37.47	10.53	0.00	10.53	2.24	2.70	4.94
Ireland	1998	26.30	8.30	34.61	-	-	-	5.11	1.49	6.60
Italy	2000	34.78	7.19	41.97	8.90	3.53	12.43	4.76	7.08	11.84
Netherlands	2001	41.80	8.35	50.15	3.38	0.22	3.60	0.62	3.76	4.38
New Zealand	1995/1996	31.23	9.76	40.99	14.87	0.00	14.87	5.51	11.70	17.21
Norway	2002	29.30	11.92	41.23	9.60	2.89	12.48	4.55	17.00	21.55
Poland	2000	26.32	5.21	31.53	14.31	0.40	14.71	15.07	4.52	19.59
Portugal	1999	30.59	2.49	33.08	15.70	0.00	15.70	1.55	5.91	7.46
Spain	1995	32.01	5.84	37.84	3.17	0.63	3.80	5.77	5.69	11.46
Sweden	2001	32.34	2.93	35.26	10.72	0.17	10.89	1.26	4.50	5.76
United Kingdom	1995	40.89	7.80	48.69	5.76	1.42	7.19	8.49	5.18	13.67
United States	1997	40.93	1.82	42.75	13.88	1.58	15.46	9.46	3.06	12.53

Table 5 clearly shows that total distribution margins on household consumption goods are much larger than those applied to investment or export goods. Total distribution margins in household consumption range from a low of 32% of purchaser prices in Estonia to a high of 50% in the Netherlands. Distribution margins are above 33% for almost all countries in the sample (excepting Estonia and Portugal). By contrast, distribution margins in fixed capital formation are substantially lower. The largest distribution margin in fixed capital formation, for Austria, is 18.16%, followed by Denmark and Belgium. Distribution margins in fixed capital formation are below 10% of purchaser costs for 7 out of 19 countries in the sample. Margins in exports are also smaller than margins in household consumption. The average distribution margin in export industries is 13%, with a wide range in their values. Nordic European countries tend to have very low distribution margins on exports, with relatively large margins on household consumption.

The contribution of wholesale-retail and transportation to the total distribution margins also varies by final demand component. While transportation accounts for a significant portion of total distribution margin in exports, its contributions to the total margins for consumption and gross-fixed capital formation are significantly lower. For 11 countries in the sample the transport margin in exports is larger than the wholesale-retail margin. In household consumption, the country with the largest transportation margin relative to the wholesale-retail portion is Norway, with transportation margins being 40% of the size of the wholesale-retail margins. For the typical country, transport margins make up less than 20% of the total margin in consumption. Finally, transportation margins are particularly low for gross-fixed capital formation. The median transportation margin in investment is 0.6%. Wholesale and retail margins are also significantly lower for investment relative to other final demand components, but even after taking this into consideration, the relative contribution of transportation to total margins is lower for investment.

D. Imported Inputs into Production

We measure the size of imported inputs for all industries in the input-output tables. For comparison with the distribution margins, we report in the first columns of Tables 3 and 4 the imported input measures calculated for the same set of industries for which we have calculated distribution margins, i.e. for 29 homogeneous manufacturing and primary-industry groupings. A clear pattern emerges from Table 3. Industries involved in agriculture and commodity production have much lower shares of imported inputs than industries in the manufacturing sector. For instance, Forestry, Logging and Related Services and Coal and Lignite have imported input shares of around 13% of total costs. By contrast, all manufacturing industries have imported input shares above 20%. Within the manufacturing sector, chemicals has the largest share of imported inputs, 67% of total costs, followed by electrical machinery and medical and precision instruments, both with imported input shares above 50%. The industries within manufacturing with the lowest imported input shares are forestry and metal ores.

The dispersion of imported inputs into production also differs significantly by country. Table 4 reports the average imported inputs into production for all industries. This measure includes not only the industries reported in Table 3 but also other industries such as Electricity, Transportation, Trading, Insurance, Finance and Other Services. In general, larger countries have a lower share of imported inputs into production while smaller countries have a higher share. The United States has the lowest ratio of imported inputs into production of all countries in the sample, although its data are not fully comparable since it refers only to manufacturing industries. The next lowest is France. Ireland, with 49%, has by far the largest ratio of imported inputs into production. Other smaller countries like Belgium, Hungary and Portugal also have large ratios of imported inputs into production.

The role of imported inputs differs substantially between manufacturing industries and other industries. We already discussed that manufacturing industries have a much larger share of imported inputs than Agriculture and Mining. In the appendix we present the ratio of imported inputs in the production of other non-manufacturing industries, mainly Energy, Construction, Transportation, and Services. Imported inputs have a large share of costs of production mainly in those industries with a large consumption of energy products as raw materials. These industries include Electricity, Gas, Steam, Water and Air Transport. Imported inputs are also important for Repair of Motor Vehicles as auto parts are a highly tradable industry. For the other non-manufacturing industries, imported inputs play a minor role, with ratios almost always below 20% of production costs.

E. Do Distribution Margins Respond to Exchange Rate Fluctuations?

As discussed in section 2, exchange rates may influence profit margins, both at the level of initial producers and again at the level of wholesalers and retailers. The specific size of this relationship depends on the competitive structures assumed and the relationship between the foreign producer and the local distributor. In this section we use the data available on distributor margins to explore evidence of their responsiveness to exchange rate fluctuations.

Some of the countries in our panel have multiple years of margin data that can be used for time-series panel construction. These data do not distinguish between markups for foreign versus domestic producers, nor do they distinguish margins by different components of final demand. The data span is 1995 to 2001 for Belgium, Denmark, France, Germany, Italy, Spain, and the United Kingdom, and 1995 to 2002 for the United States.

The time-series panel regression specification we use is given by equation (11)

$$\Delta m_t^c = \alpha_t + \alpha_c + \alpha_c \Delta X_t^c + \varepsilon_t \tag{11}$$

where Δ indicates first differences in the logarithm of the variable in country c. We introduce some combination of country and year fixed effects and ΔX_t^c variables that are country-specific nominal and real exchange rates. The results reported in Table 6 are the correlations between changes in the distribution margin (wholesale, retail plus transportation) of total final demand relative to changes in the nominal and the real effective exchange rate of each country.

There are three reasons the results will likely understate the sensitivity of margins to exchange rates. First, the relevant data are available only for total distribution margins, and not for the decomposition into the trade versus transportation components. Ideally, we would focus only on the wholesale and retail component, which ex ante is likely to be more elastic than the transport and storage component of the margins. As shown in Tables 4 and 5, however, this is not a first-order concern because most industries have the majority of their distribution costs associated with the wholesale and retail component. Second, these data are much broader than our other sources: it is at the level of countries, rather than industries, and aggregates margins on investment spending, exports, and government demand. As a consequence, we expect the results to yield elasticities much smaller in absolute terms than would be expected specifically for retail margins on consumption goods. Third, the distribution expenditures are across home tradable and imported goods. We will be unable to disentangle $\eta^{m(h),e}$ from $\eta^{m(f),e}$ and instead will be observing a weighted average of the two terms.

Across countries, even with the shortcomings of the aggregate data described above, we find that home currency depreciations are associated with lowered distribution margins. Expenditures on wholesalers and retailers (or distributor markups) are smaller in periods when imports are more expensive. This effect is statistically significant when the real exchange rate is used, and it is very robust to the inclusion of country and/or time effects. A 1% real depreciation of the real exchange rate results in a 0.47% decrease in distribution margins. The correlation between nominal exchange rates and distribution margins is also negative, although only statistically significant in specifications that exclude fixed effects.

More compelling numerical estimates of actual distribution expenditure for $\eta^{m(h),e}$ and $\eta^{m(f),e}$ are starting to be available from detailed producer and industry studies, as opposed to the aggregate industry data of our sample. Hellerstein (2004), for example, uses wholesale and retail prices for specific goods in the beer industry to show that retailers and producers share the burden of profit adjustment in response to exchange rate fluctuations. In this market, the impact of exchange rate fluctuations on the U.S. economy appears to be damped by strategic interactions between domestic and foreign firms in the traded goods sector, as well as between these firms and the domestic firms in the nontraded sector. Foreign firms may be purchasing insurance for exchange rate volatility from domestic retailers in the form of higher retail markups in exchange for greater variability in these markups. The Hellerstein (2004) analysis of the beer market in the United States finds that a 1% depreciation of the dollar with respect to the euro is associated with a 0.50% decrease of retail margins for European brands, a .30% decrease in the retail margins of competing (but unaffected) imported brands (primarily brands from Canada and Mexico), and a 0.10% decrease in the retail margins of domestic brands. If one limits the last number to import competing domestic brands (light beers), the retail margins decrease by 0.20%. But as both "import competing" and non-import competing brands are included in our data on tradable domestic goods, the 0.10 number is the most relevant. These estimates appear within the same ball park as those reported for the aggregate distribution margins of a country reported in Table 7. In work on the automobile industry, Hellerstein and Villas-Boas (2006) show that the margins on domestic brands that are not close substitutes for imported brands rise by roughly 0.10% following a 1% dollar depreciation.

Table 6. Sensitivity of Distribution Margins to Exchange Rates

	Nominal			Real		
Elasticity	**-0.359***	-0.257	-0.315	**-0.477****	**-0.476****	**-0.453****
t-stat	*1.78*	*0.96*	*1.32*	*2.99*	*2.15*	*2.45*
country	no	yes	no	no	yes	no
year	no	no	yes	no	no	yes
R-squared	0.06	0.14	0.17	0.18	0.24	0.27
Number Obs.	37	37	37	37	37	37

The dependent variable is the distribution margin for final demand for the following countries: Belgium, Denmark, France, Germany, Italy, Spain, UK and U.S. for the period 1995 to 2001, except for the U.S. in which the data go from 1995 to 2002. The nominal and real effective exchange rates are the reu and neu measures from the IMF, International Financial Statistics database.

* Significant at the 10% level **Significant at the 5% level.

F. Consumption, Trade Shares, and Elasticity Estimates

Calibration of the pass-through elasticities requires information on the shares of tradables in consumption, imports in tradables, and imported inputs relative to production costs. We compute these shares using the information from the country Input-Output data. We follow the OECD industry classification reported in Appendix Table 1.[12] The data are provided in Table 7 for

[12] In our constructions, the share of tradables in consumption is the sum of final consumption from OECD industries 1 to 24, divided by total final consumption net of consumption in wholesale and retail (OECD industry 27), and distribution (OECD industry 29). The nontradables industries are from OECD industry 25 and higher, excluding industry 27 and 29, picking up domestic services, electricity, gas and water. The import share of tradables is computed as the sum of imports in the final consumption for industry 1 through 24, relative to the sum of total consumption across these industries. Imported inputs into nontradables is the sum of imports into intermediate consumption for industries 25 and higher, excluding industry 27 and 29, relative to total intermediate inputs consumption for these same industries. Finally, the share of imported inputs in tradables production is the sum of imports into intermediate consumption for industries 1 through 24 relative to total intermediate inputs consumption for these same industries.

twenty-one countries. The share of tradable goods in consumption ranges from 25% for the US to 59% for Estonia, and is typically about 35%. Imports as a share of tradables consumption also varies considerably across countries, from the US at 20% to Denmark at 59%. With imports in tradables consumption on the order of 25 to 35%, the resulting share of imports in overall consumption is between 5 and 15%.

Table 7: Trade and Imported Input Shares

Country	I-O year	Imports to Tradables $1-\alpha_T$	Tradables to Consumption α	Imported inputs relative to costs in tradable production $\mu(h:e)$	Imported inputs relative to costs in nontradables $\mu(n:e)$
Australia*†	2000/2001	0.27	0.31	0.18	0.09
Austria	2000	0.59	0.33	0.43	0.15
Belgium	2000	0.55	0.34	0.48	0.15
Denmark	2000	0.59	0.28	0.33	0.10
Estonia	1997	0.57	0.59	0.42	0.22
Finland	2002	0.42	0.26	0.29	0.10
France	2000	0.24	0.38	0.20	0.08
Germany	2000	0.33	0.36	0.27	0.09
Greece	1998	0.57	0.39	n.a.	n.a.
Hungary*	2000	0.34	0.43	0.41	0.22
Ireland	1998	0.47	0.41	0.49	0.35
Italy	2000	0.26	0.40	0.24	0.09
Netherlands	2001	0.57	0.26	0.41	0.14
New Zealand*	1995/1996	0.31	0.38	0.27	0.07
Norway	2002	0.46	0.34	0.25	0.14
Poland	2000	0.25	0.47	0.24	0.07
Portugal	1999	0.45	0.42	0.37	0.14
Spain	1995	0.25	0.35	0.22	0.08
Sweden	2000	0.47	0.26	0.35	0.16
United Kingdom	1995	0.34	0.34	0.25	0.10
United States	1997	0.20	0.25	0.10	0.03

* These data are computed from individual country-specific source data, based on purchasers' prices. The other countries presented in the table have shares computed using a harmonized OECD database, with valuations using basic prices.

n.a. = not available.

† For Australia the ratio of imported inputs in the production of tradables and nontradables refer to 1994/95 I-O benchmark tables from the OECD.

The last two columns of Table 7 present the share of imported inputs in tradable and nontradable goods production. These data clearly show the large reliance on imported components by certain countries, especially in the production of tradables.[13] Tradables' use of imported components ranges from 10% of total costs in the U.S. (in 1997, prior to the late 1990s' acceleration of internationally integrated production) up to 49% for Ireland. While calibrations usually treat nontraded goods production as using only domestic inputs, the data show that the share of

[13] Campa and Goldberg (1997) explore cross-country and cross-industry imported input use for a smaller sample of countries.

imported inputs in the production of nontraded goods ranges from 3 to 35% of production costs inclusive of labor costs, with a value typically around 10%.

IV. Calibrated Pass-through into Import Prices and the CPI

This section addresses the predictions of the model in two dimensions: 1) price elasticities with respect to exchange rates for nontraded, home tradable, and imported goods and 2) the values these elasticities imply for transmission rates from exchange rate movements into the CPI. We begin by generating predicted rates of exchange rate pass-through into home tradable goods, imported goods, and home nontraded goods prices using plausible parameters for the model calibrations and the rich data on distribution margins, imported input shares, and consumption shares. We generate model-based predictions of exchange rate pass-through into the CPI, and a variant on these predictions that uses estimated import price elasticities, showing the sensitivity of all predictions to assumed parameters of the models.

The calibration requires values for the demand elasticity (θ), elasticities of substitution among groups of products, and elasticities of response to exchange rates of distribution margins and imported inputs.[14] Following Corsetti, Dedola, and Leduc (2004), we use demand elasticity estimates, θ, that are consistent with the steady state price over cost markups, defined by $markup = \theta/(\theta - 1)$, reported in the literature. Basu and Fernald (1997) find markups for United States industries in the range of 11%. Oliveira Martins, Scarpetta, and Pilat (1996), after examining 14 OECD countries and 36 manufacturing industries, find markups generally ranging between 10 and 35%. These markup values imply values of θ between 10 and 4. Higher values of pass-through into home tradables are generated when we assume lower demand elasticities. For the elasticity of substitution between tradable and nontradable goods, Stockman and Tesar (1995) report, based on a sample of 30 countries, an elasticity of substitution between tradable and nontraded goods at $1/(1-\phi) = 0.44$ (yielding $\phi = 2.27$). However, this parameter will not come into play in the calibrations provided below because we will assume unity between the initial relative prices of imported and home tradables, and of home tradables and nontradables.

We assume imported input share elasticities to exchange rates of either 0 or -0.10. Furthermore, we assume that these elasticities are identical across the production of nontradables and home tradables. Under these assumptions, a home currency depreciation of 1% either has no effect on the volume of imported inputs used, or decreases imported input share by 0.10%.

We assume larger elasticities for distribution margins, consistent with the empirical evidence on this point reported in Table 7. We assume values for $\eta^{m(f:e),e}$ between 0 and -0.50; in response to a 1% home currency depreciation, distributors can either leave margins on home tradables unchanged, $\eta^{m(h:e),e} = 0$, or lower margins by 0.50%.[15]

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[14] The calibrations basically shut down the role of initial conditions and substitution between tradable and nontradable goods by setting the relative price terms to equal one in the calculations. Accordingly, values of ϕ do not matter for these calibrations. Corsetti, Dedola, and Leduc (2004) use $1/(1-\phi) = 0.77$, implying $\phi = 1.3$, based on Mendoza (1991).

[15] We also have not experimented here with the state-contingent markup changes associated with productivity differences across countries, although we have all the mechanisms in place for such comparisons.

Table 8 reports our model's predictions of price elasticities of response to exchange rates. Recall that these elasticities are all derived under the monopolistic competition structure. This assumption implies that pass-through of exchange rates into nontraded goods prices and home tradables occurs because of the existence of imported inputs whose prices are sensitive to exchange rates. In imported goods, pass-through of exchange rates is stronger, dipping below 1 only to the extent that distribution costs add value in the local economy and adjust to exchange rate changes.[16] As indicated above, we calibrate the results for two possible rates of this adjustment of distribution margins to exchange rates, 0 and -50%.

Table 8. Calibrated Price Elasticities with Respect to Exchange Rates

	$\eta^{p(n),e}$ nontraded goods prices		$\eta^{p(h),e}$ home tradables prices		$\eta^{p(f),e}$ imported goods prices			
	θ=4	θ=10	θ=4	θ=10	θ=4		θ=10	
					$\eta^{m(f),e}$ =0	$\eta^{m(f),e}$ = -0.5	$\eta^{m(f),e}$ =0	$\eta^{m(f),e}$ = -0.5
Australia	0.12	0.10	0.31	0.25	0.52	0.25	0.59	0.36
Austria	0.20	0.17	0.69	0.56	0.52	0.22	0.59	0.34
Belgium	0.20	0.17	0.74	0.60	0.63	0.40	0.68	0.49
Denmark	0.13	0.11	0.53	0.43	0.47	0.16	0.54	0.29
Estonia	0.30	0.25	0.69	0.55	0.70	0.49	0.73	0.56
Finland	0.14	0.11	0.47	0.38	0.42	0.09	0.51	0.23
France	0.11	0.09	0.31	0.25	0.60	0.38	0.66	0.48
Germany	0.13	0.10	0.43	0.35	0.53	0.26	0.60	0.38
Greece	0.20	0.17	0.63	0.51	0.60	0.35	0.65	0.44
Hungary	0.29	0.24	0.70	0.56	0.65	0.40	0.68	0.48
Ireland	0.46	0.39	0.86	0.69	0.75	0.52	0.76	0.57
Italy	0.12	0.10	0.39	0.31	0.50	0.23	0.58	0.35
Netherlands	0.19	0.16	0.68	0.55	0.46	0.12	0.53	0.25
New Zealand	0.09	0.08	0.41	0.34	0.50	0.23	0.58	0.35
Norway	0.19	0.16	0.44	0.35	0.55	0.28	0.61	0.38
Poland	0.09	0.08	0.36	0.30	0.62	0.41	0.68	0.50
Portugal	0.19	0.15	0.57	0.47	0.64	0.42	0.69	0.51
Spain	0.11	0.09	0.35	0.28	0.55	0.30	0.62	0.41
Sweden	0.22	0.18	0.56	0.46	0.63	0.40	0.68	0.48
U. Kingdom	0.14	0.12	0.42	0.34	0.44	0.12	0.52	0.25
United States	0.04	0.04	0.16	0.13	0.45	0.17	0.54	0.31

Note: Assumes: Greece μ(h)=0.40, μ(n)=0.15; for Australia assumes the distribution margin shares of New Zealand; the share of imported inputs in production does not change with exchange rate changes, that the elasticities on home tradeables distribution margins are 0; and normalizes ew*/Zf=1.

[16] Of course, the empirical evidence on border prices generally finds less than complete pass-through of exchange rates into border prices, as demonstrated by the results shown in Table 1 on import prices and by the other related studies cited. This implies that the calibration results are likely to overstate exchange rate pass-through into the respective price series, and into the aggregate CPI.

The first two data columns of Table 8 show pass-through into nontraded goods prices (equation 6) across countries, and the sensitivity of such pass-through to the assumption of demand elasticity, θ, valued at 4 or 10. The next two columns provide calibrated exchange-rate pass-through into home tradables prices (equation 7). The final group of columns explores the sensitivity to exchange rates of the consumption prices of imported goods (equation 8), under alternative assumptions about demand elasticities and distributor margin responses to exchange rates.

Comparisons of columns (1) and (2) and columns (3) and (4) confirm the effects of different demand elasticities on exchange rate pass-through results. Lower demand elasticities are associated with higher producer markups. At the same time, higher imported input costs from a home currency depreciation lead to more pass-through into prices of nontradable and home tradable goods. Furthermore, home tradables producers tend to rely more heavily on imported inputs than nontradables producers do, so the resulting exchange rate pass-through into home tradables is higher [comparison of columns (1) and (3)]. Huge cross-country differences in imported input use generate levels of calibrated pass-through in nontradables prices that are ten times greater in Ireland than in the United States, with home tradables pass-through five times greater.

The last four columns of Table 8 focus on pass-through into the consumption prices of imported goods, i.e. prices including distribution costs in local currency. Column (5) shows that adding a distribution sector with local costs drives a large wedge between complete pass-through and the new calibrated pass-through for imported goods prices. Distribution margin sensitivity to exchange rates, with distributors lowering markups when the home currency depreciates, further reduces the sensitivity of consumption prices of imports to exchange rates. However, these distribution margin reactions cannot eliminate pass-through because distribution services also require imported inputs, which have costs sensitive to exchange rates. Thus, we observe pass-through into the consumption prices of imported goods to be lowest for countries with high distribution shares, as is the case for the Netherlands, Finland, and the United Kingdom, when margins are adjusted to offset the effects of exchange rates $\eta^{m(f:e),e}$ = -0.50 (instead of = 0), and when imported input shares are small in the nontraded goods sector.

Four key parameter assumptions influence the values reported in Table 8: the demand elasticity, the elasticities of imported input shares and of distribution margins in the different types of goods, and the real marginal cost in the production of foreign goods. While Table 8 has allowed for differences in demand elasticities, Table 9 explores the impact on these exchange-rate pass-through elasticities of changes in two additional parameters: the pass-through of exchange rate movements via imported input shares and distribution margins to prices in domestic currency of imports, domestically produced tradables, and nontradables, with a focus only on estimates for the United States. Comparing columns (1) and (2) of this table: when the distribution margin on imported goods is sensitive to exchange rates, the effect is a reduced sensitivity of consumption prices of imports to exchange rates. If this force is strong enough, and in the absence of imported inputs for the nontraded sector, exchange rate pass-through into the consumer prices of imported goods could resemble local currency pricing, as Devereux and Engel (2002) have argued. When distribution margins on home tradables are sensitive to exchange rates, and if this sensitivity goes in the direction of increasing the margins when competing imports become more expensive, exchange rate pass-through into home tradables is increased (columns 3, 4). Finally, allowing for substitution out of some imported inputs (columns 5, 6) directly reduces pass-through into nontraded goods prices and home tradables prices, and has an additional indirect downward effect on pass-through of home tradables and imported goods by reducing transmission of exchange rates through distribution sector costs.

Table 9. U.S. Exchange Rate Pass-through Elasticities, under alternative assumptions

assumptions	(1)	(2)	(3)	(4)	(5)	(6)	(7)
θ	4	4.00	4.00	4.00	4.00	4.00	4.00
$\eta^{\mu(n),e} = \eta^{\mu(h),e}$	0	0.00	0.00	0.00	-0.10	-0.10	-0.10
$\eta^{m(h),e}$	0	0.00	0.10	0.10	0.00	0.10	0.10
$\eta^{m(f),e}$	0	-0.50	0.00	-0.50	-0.50	0.00	-0.50
ew*/zf	1	1.00	1.00	1.00	1	1.00	1.00
results							
$\eta^{p(n),e}$	0.040	0.040	0.040	0.040	0.036	0.036	0.036
$\eta^{p(h),e}$	0.156	0.156	0.213	0.213	0.141	0.198	0.198
$\eta^{p(f),e}$	0.453	0.168	0.453	0.168	0.165	0.450	0.165
$\eta^{cpi,e}$	0.084	0.070	0.095	0.081	0.063	0.089	0.075

As a final exercise, we bring all of these findings together to inform the question of what exchange rate pass-through into CPIs is expected, given the features of each economy observed in the data and assumed in the calibration exercises. The first relevant set of data is the degrees to which different price elasticities feed into CPI sensitivity to exchange rates, based on the shares of each type of good in the index (see equation 10). These CPI weights are computed and presented in the first three data columns of Table 10. Clearly, nontraded goods have the largest weights in CPIs across all countries, ranging from a low of 0.41 for Estonia to a high of 0.75 for the United States. The home tradables weight ranges from 0.11 for the Netherlands and Denmark, to nearly 0.30 across a number of larger countries. The weight on imported goods ranges from a low of 0.05 for the United States to a high of 0.34 for Estonia.

The remaining data columns of Table 10 address actual and calibrated exchange rate pass-through into consumer price indices across twenty-one countries. In column (4) we reproduce estimates of exchange rate pass-through in CPIs, previously reported in Table 1.[17] Columns (5) through (8) present calibrated CPI pass-through, under benchmark assumptions of θ = 4, $\eta^{m(f:e),e}$ = 0 or -0.50, and other elasticity parameters at 0. Columns (5) and (6) are the result of multiplying the corresponding weights for each type of good reported in columns (1) to (3) of this table with the corresponding calibrated elasticities for that type of good from Table 8, where exchange rates pass-through completely into border prices, and distribution margins and imported input use are the main reasons for deviations from full exchange rate pass-through into consumption prices. Columns (7) and (8) embed the recognition that exchange rate pass-through into border prices is incomplete. This incomplete pass-through essentially weights downward the calibrated numbers of columns (5) and (6), on average by about 50%.

[17] Appendix results show that VAR methods produce similar CPI pass-through elasticities.

Table 10. Exchange Rate Pass-through into the CPI

	Weight on Price Elasticities in the CPI Elasticity			Exchange Rate Pass-through into CPI				
				Estimated	Calibrated, θ = 4			
	$\eta^{p(h),e}$ weight (1)	$\eta^{p(f),e}$ weight (2)	$\eta^{p(n:e),e}$ weight (3)	Reproduced From Table 1 (4)	Assuming $\eta^{m(f:e),e}$ = 0 (5)	Assuming $\eta^{m(f:e),e}$ = -.5 (6)	Assuming estimated import price pass-through and assuming $\eta^{m(f:e),e}$ = 0 (7)	-0.5 (8)
Australia	0.23	0.08	0.69	0.09*	0.20	0.17	0.13	0.12
Austria	0.14	0.20	0.67	-0.09	0.33	0.27	0.03	0.03
Belgium	0.15	0.19	0.66	0.08+	0.36	0.32	0.25	0.22
Denmark	0.11	0.16	0.72	0.16*+	0.23	0.18	0.19	0.15
Estonia	0.25	0.34	0.41		0.53	0.46		
Finland	0.15	0.11	0.74	-0.02 +	0.22	0.18	0.17	0.14
France	0.29	0.09	0.62	0.48*+	0.21	0.19	0.21	0.19
Germany	0.24	0.12	0.64	0.07+	0.25	0.22	0.20	0.17
Greece	0.17	0.23	0.61		0.36	0.31		
Hungary	0.28	0.14	0.57	0.42*+	0.46	0.42	0.36	0.33
Ireland	0.21	0.19	0.59	0.08+	0.61	0.56	0.04	0.03
Italy	0.29	0.10	0.60	0.03+	0.24	0.21	0.08	0.07
Netherlands	0.11	0.15	0.74	0.38*+	0.29	0.24	0.24	0.20
New Zealand	0.26	0.12	0.62	-0.10*+	0.23	0.19	0.05	0.04
Norway	0.19	0.16	0.66	0.08+	0.29	0.25	0.18	0.16
Poland	0.35	0.12	0.53	0.59*+	0.25	0.23	0.20	0.18
Portugal	0.23	0.19	0.58	0.60*+	0.36	0.32	0.39	0.35
Spain	0.26	0.09	0.65	0.36*+	0.21	0.19	0.15	0.13
Sweden	0.14	0.12	0.74	-0.11 +	0.32	0.29	0.12	0.11
United Kingdom	0.23	0.11	0.66	-0.11+	0.24	0.20	0.11	0.09
United States	0.20	0.05	0.75	0.01+	0.08	0.07	0.04	0.03
Average	**0.21**	**0.15**	**0.64**	**0.16**	**0.30**	**0.26**	**0.15**	**0.13**

* (+) indicates exchange rate pass-through significantly different from zero (one) at a 5% confidence level.

Calibration results predict exchange rate pass-through into the CPI that averages between 30% and 13%, depending on what is assumed about the double-marginalization process and what is assumed on exchange rate pass-through into import prices at the border. In all cases, predicted cross-country differences can be substantial. The highest calibrated exchange rate pass-through into the CPI occurs in Ireland, Estonia, and Hungary, at over 40% (columns 5 and 6). The lowest calibrated pass-through is for the United States. A much larger group of countries are in intermediate ranges of calibrated exchange rate pass-through into the CPI, between 20 and 30%. A number of European countries have actual CPI sensitivities higher than their calibrated values, but more typically the predictions are correlated with actual (noisy) estimates and similar magnitudes.

Among these countries, consider the relative importance of imported inputs and distribution margins in driving exchange rate pass-through into the CPI. To analyze this relative contribution we calibrate the hypothetical exchange rate pass-through into CPIs under the three alternative assumptions: eliminating imported inputs into the economy, eliminating distribution costs, and eliminating both effects at once.

These newly calibrated pass-throughs into the CPIs are reported in the last four columns of Table 11. The first two columns of Table 12 reproduce the calibrated pass-through elasticities to CPIs reported in Table 10. The next two columns, where imported inputs are zero, starkly demonstrate how important these imported inputs are for exchange rate pass-through into consumer prices in this model. Higher imported inputs contribute to the price of nontradable goods, which have the largest weight on the CPI, and also have an indirect impact on the price of home-produced tradable products. Since nontradables are a part of the final consumption value of both home tradables and imported consumption goods, the role of transmission through imported input costs is further magnified. These effects combined account for the vast majority of the sensitivity of CPIs to exchange rates in the model. Columns (3) and (4) show that the pass-through drops by almost 75% in all countries under a counterfactual with no imported inputs in production. The average pass-through for all countries drops from 0.16 to 0.04.

Table 11. Exchange Rate Pass-through into the CPI under alternative scenarios

	Assuming estimated import price pass-through, and $\eta^{m(f:e),e}$ = 0 or -0.50					
Country	**Base Case***		**No Imported Inputs**		**No distribution costs**	**Neither imported inputs nor distribution costs**
	$\eta^{m(f:e),e}$ =0	$\eta^{m(f:e),e}$ =-.5	$\eta^{m(f:e),e}$ =0	$\eta^{m(f:e),e}$ =-.5	$\eta^{m(f:e),e}$ =0 or =-0.5	$\eta^{m(f:e),e}$ =0 or =-0.5
Australia	0.13	0.12	0.03	0.01	0.15	0.06
Austria	0.03	0.03	0.01	0.00	0.04	0.02
Belgium	0.25	0.22	0.07	0.04	0.28	0.13
Denmark	0.19	0.15	0.05	0.01	0.25	0.13
Estonia	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Finland	0.17	0.14	0.03	0.00	0.21	0.09
France	0.21	0.19	0.05	0.03	0.23	0.09
Germany	0.20	0.17	0.04	0.02	0.23	0.09
Greece	0.00	0.00	0.00	0.00	0.00	0.00
Hungary	0.36	0.33	0.06	0.03	0.36	0.11
Ireland	0.04	0.03	0.01	0.00	0.04	0.01
Italy	0.08	0.07	0.02	0.01	0.09	0.04
Netherlands	0.24	0.20	0.04	0.00	0.30	0.13
New Zealand	0.05	0.04	0.01	0.00	0.06	0.03
Norway	0.18	0.16	0.04	0.02	0.22	0.10
Poland	0.20	0.18	0.05	0.03	0.22	0.09
Portugal	0.39	0.35	0.12	0.07	0.45	0.21
Spain	0.15	0.13	0.03	0.02	0.16	0.06
Sweden	0.12	0.11	0.02	0.01	0.13	0.05
United Kingdom	0.11	0.09	0.02	0.00	0.13	0.05
United States	0.04	0.03	0.02	0.02	0.04	0.03
Average	**0.16**	**0.14**	**0.04**	**0.02**	**0.18**	**0.08**

* Columns 7 and 8 of Table 10.

Distribution costs, as expected, decrease the pass-through of exchange rates into CPIs. Distribution expenditures add local content to imported consumption goods, thereby reducing the share of the final consumption good directly linked to border prices, and can be adjusted through double marginalization. The effect of eliminating these distribution costs appears to be quantitatively smaller than the effects of eliminating imported inputs. Under a counterfactual with no distribution costs, estimated pass-through elasticities increase, on average, by nearly 30% when there is no double marginalization, and by 12.5% when distributor margins elasticities are set at -0.5. The average pass-through for all the countries increases from 0.14 or 0.16 to 0.18. Eliminating distribution margins has a smaller effect on CPI pass-through than eliminating imported inputs because the distribution margins are operating on a smaller part of the consumption basket. By assumption, nontradables, the largest part of the basket, have zero distribution costs.

Overall, this section has found that the pass-through elasticity of exchange rates into CPIs highly depends on the role that tradable goods have in the economy – both tradables in consumption and imported inputs in production. While the pass-through of exchange rates is strongest into import prices, pass-through into nontraded goods prices and home tradables prices, mainly due to reliance on imported inputs, also contribute to overall CPI pass-through. Demand elasticities play a key role in the scale of calibrated import price pass-through elasticities. Distribution margins are important for damping border price pass-through into consumption prices, but also enhance pass-through because distribution expenditure for all tradables is sensitive to the nontradable sector's reliance on imported inputs. Imported inputs thus matter both for the prices of directly consumed nontradable goods and for tradable goods in the final consumption baskets of most developed economies.

V. Conclusions

This paper explores the channels for transmission of exchange rates into various types of consumption goods prices and into the aggregate level of prices across twenty-one economies. For this analysis, we provide extensive cross-country evidence on the size of the distribution sector, the degree of openness, the size of the nontradable sector, and the amount of imported inputs in each economy. We establish that distribution costs, relevant for consumer price pass-through calculations, are on average 32 to 50% of the total cost of goods across OECD countries. Such distribution margins are attributable mainly to the costs of wholesale and retail services, except in the case of mining and ore related industries where transportation costs play a much larger role and wholesalers and retailers provide less measured value added. We also document that imported input use is larger in tradable goods industries than in nontradables production, and varies widely across countries.

In regressions over a smaller sample of countries, and using changes over time in distribution margins, we find evidence that exchange rate movements influence margins. The reduction in expenditures on distribution when a local currency depreciates is consistent with a process of double-marginalization, in which the distributors have an added role in delinking border prices from final consumption prices. These results complement other channels for price insensitivity, such as those emphasized by Burstein, Eichenbaum and Rebelo (2003), who show that following a domestic currency depreciation, home consumers substitute away from more expensive and higher quality imports toward lower quality domestically produced goods. The substitutability implies that the weight on foreign products in the CPI, and the overall quality mix of consumption, is responsive to exchange rate fluctuations. This type of argument is especially plausible for those countries that have pursued import substitution strategies and have domestic substitutes for a substantial part of the import bundle.

These arguments do not, however, imply that the CPI is completely insulated from exchange rates. Distribution margins, in addition to insulating consumption prices from exchange rate fluctuations, also provide an added channel for transmission of exchange rate pass-through. The channel exists because of the extensive use of imported inputs in production, in nontraded goods as well as in tradable goods. The cost of distribution services, required for both home tradables and imported goods, becomes sensitive to exchange rates. Overall, we find that exchange rate pass-through into consumer prices is predicted to average between 13 and 30%, but is expected to be substantially lower for the United States.

We have not addressed the possibility that low CPI sensitivity to exchange rates results from monetary reaction functions, or monetary credibility in general. Countries with inflation targeting regimes, or more generally with monetary authorities that lean against the wind via their policy reaction functions, move to offset the inflationary shock to the local economy transmitted through import prices. As Gagnon and Ihrig (2002), Bailey (2002), and Bailliu and Fujii (2004) argue, a depreciation would be met with a corresponding monetary tightening. If this were the dominant explanation for the disconnect, we would also expect to see the relative prices of traded and nontraded goods diverge in the aftermath of an exchange rate shock as, for example, the prices of domestic non-traded goods decline with monetary tightening and offset the inflationary stimulus transmitted initially through traded goods prices.

Overall, our results are a step further in a broad research agenda on the transmission of international shocks. Future empirical research can embed recent advances with alternative assumptions of producer strategic interactions and introduce dynamic price adjustment, richer treatment of the demand elasticities facing producers, and better specified behavioral equations for the distribution sectors. However, we have demonstrated that distribution margins and imported input expenditures are expected to be crucial features of exchange rate pass-through across countries. These features should be embedded in continuing research on international shock transmission, patterns of global adjustments, and work on associated welfare consequences.

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DATA APPENDIX

Pass-through estimation

Methodologically, we follow the approach to estimation laid out in Campa and Goldberg (2005), expressed in first-differences, with the addition of lagged exchange rate and foreign production cost terms to allow for the possibility of gradual adjustment of import prices or the CPI to exchange rates, the OLS estimation equation is:

$$\Delta p_t^j = \alpha + \sum_{i=0}^{-4} a_i^j \Delta e_{t-i}^j + \sum_{i=0}^{-4} b_i^j \Delta w_{t-i}^j + c^j \Delta gdp_t^j + \vartheta_t^j$$

where p_t are local currency import prices or the local consumer price index, e_t is the exchange rate, w_t is the foreign production costs, and gdp_t is real GDP. The short-run relationship between exchange rates and the respective price series of country *j* is given by the estimated coefficient a_0^j. The long-run elasticity, reported in Table 1, is given by the sum of the coefficients on the contemporaneous exchange rate and four lags of exchange rate terms $\sum_{i=0}^{-4} a_i^j$.

We include up to four lags of exchange rates and foreign prices/production costs in the regression. Most of the pass-through response occurs over the first and second lags after an exchange rate change, so the interpretation of four quarters as long run is empirically validated. While the theoretical antecedents of this equation are log-level relationships among variables, for estimation the variables in these equations are first-difference to control for the possibility of unit roots in the time series variables contained in these specifications.

OECD import price series: Source: OECD Statistical Compendium. Quarterly time series of aggregate import price indices in local currency for 1975:Q1 to approximately 2003:Q1. As of 2004:Q1, when we extracted these data, most countries had end datapoints for these series ranging from 2002:Q3 to 2003:Q1. We work with the maximum amount of data available by country in our analysis.

Effective Exchange Rate Indices. The nominal exchange rate index is the trade-weighted exchange rate index provided by the IMF. Code in IFS database: neu. The real effective exchange rate used is code reu. Regression analysis uses the inverse of the reported series, so that an increase in the exchange rate is a currency depreciation.

Foreign Price Index. We construct a consolidated export partners cost proxy by taking advantage of the IFS reporting of both real (*reu*) and nominal (*neu*) exchange rate series and computing $W_t^{x,j} = neu_t^j \cdot P_t^j / reu_t^j$ by each country in our sample. This gives us a measure of trading partner costs (over all partners *x* of importing country *j*), with each partner weighted by its importance in the importing country's trade. The real effective exchange rate is calculated from Unit Labor Costs for developed countries by the IMF. *Code in IFS database*: reu. The consumer price indices from the *International Financial Statistics. Code in IFS database: 64.*

Structural VAR Estimation of pass-through coefficients

An alternative approach for the estimation of the pass-through coefficients in equation (1) and reported in Table 1 is to estimate a structural VAR process. The advantage of the VAR estimation in principle is twofold: first, it provides a single framework for the estimation of the pass-through effects on import and consumer prices simultaneously; and second, this framework provides a more accurate control for possible endogeneity effects among some of the exogenous variables in equation (1). The structural from of a VAR for Δy is given by

$$B\Delta y_t = b(L)\Delta y_t + u_t$$

where B is a regular matrix and $b(L)$ is a polynomial in the lag operator L and u is a white noise process, the vector of structural shocks.

The structural form of this VAR system is explained by its own lags and by contemporaneous and lagged values of all other explanatory variables. This structural form is not identified unless additional restrictions are imposed in the system. The simplest way, originally proposed by Sims (1980), is to use the Cholesky decomposition to impose restrictions in the variance of the structural shocks. The Cholesky decompositions impose a contemporaneous causal ordering on the variables, since current values of variables only depend upon current values of variables that are "above" that variable in the system.

We perform the structural estimation of a VAR system for a set of three endogenous variables: exchange rate, import prices and consumer prices. We impose the Cholesky restriction following this ordering, so that exchange rates affect import prices and consumer prices contemporaneously, and import prices also affect contemporaneously consumer prices. We treat the foreign price variable as exogenous. To facilitate the comparison between the VAR results and those reported in Table 1 in the text, we use a four-period lag length. We identify the effects of exchange rate pass-through at different horizons as the accumulated impulse response functions up to that horizon of each of the two other endogenous variables, import prices and consumer prices, to a unit structural shock in the nominal exchange rate equation.

The results from the estimation are reported in the last four columns of the table below. The first four columns of the table report the estimates from the OLS estimation of the pass-through equations. The table reports the contemporaneous effects (short) and the impact after four quarters (long) of an exchange rate shock in the import prices and in consumer prices.

The point estimates from the OLS and VAR equations are very similar. There is no obvious difference in terms of point estimates for either the time horizons of the effect (short or long run) or the domestic price examined (import prices or CPIs). The patterns of significance are essentially the same, confirming the recent results of Osbat (2005). For import prices, in the short run, rejection of a pass-through coefficient of one occurs in the large majority of countries. In the long run, a pass-through smaller than one can be rejected for a small subset of countries. For consumer prices, the degree of exchange rate pass-through is much smaller both in the short run and in the long run. A pass-through of one into consumer prices can be rejected in the long run for the vast majority of countries. In almost all countries, the estimated OLS coefficients fall within the confidence intervals of the corresponding estimated coefficients from the VAR equation, so that there is no statistical evidence of a bias in the OLS estimation from the potential endogeneity of exchange rates.

Appendix Table 1. Estimates of exchange rate pass-through

Country	OLS ESTIMATES				VAR Estimates			
	Import Prices		CPIs		Import Prices		CPIs	
	Short	Long	Short	Long	Short	Long	Short	Long
Australia	0.56*+	0.67*+	0.01+	0.09+	0.57*+	0.81*	0.04+	0.15+
Austria	0.21+	0.10	0.07	-0.09	0.40+	1.10	0.02+	0.08
Belgium	0.21+	0.68	0.06+	0.08+	0.27+	0.92+	0.06+	0.10+
Canada	0.75*+	0.65*+	-0.02+	-0.01+	0.75*+	1.40+	-0.01+	0.02+
Czech Republic	0.39*+	0.6*	0.11+	0.60*+	0.39*+	-0.05+	0.00+	0.15+
Denmark	0.43*+	0.82*	0.08+	0.16*+	0.52*+	0.92*	-0.02+	0.04+
Finland	0.56*	0.77	-0.02+	-0.02+	0.54*+	1.24+	-0.02+	-0.03
France	0.53*+	0.98*	0.10+	0.48*+	0.52*+	1.00*	-0.05+	-0.08+
Germany	0.55*+	0.80*	0.04+	0.07+	0.49*+	1.48*	0.03+	0.16+
Hungary	0.51*+	0.78*	0.00+	0.42*+	0.43*+	0.68*	0.14+	0.49*+
Ireland	0.16+	0.06	0.14+	0.08+	0.59*+	1.02*	0.06+	0.30+
Italy	0.35*+	0.35+	0.03+	0.03+	0.53*+	0.92*	0.04+	0.14+
Japan	0.43*+	1.13*	0.00+	0.11*+	0.36*+	0.84*	-0.01+	0.06+
Netherlands	0.79*+	0.84*	0.15*+	0.38*+	0.65*	1.13*	0.36+	0.59*+
New Zealand	0.22*+	0.22+	0.00+	-0.10*+	0.42*+	0.57	0.05+	0.33*+
Norway	0.40*+	0.63*	-0.01+	0.08+	0.32*+	0.58*	-0.03+	-0.09+
Poland	0.56*+	0.78*	0.00+	0.59*+	0.02+	0.13+	0.72*	2.04
Portugal	0.63*+	1.08*	0.02+	0.60*+	0.64*+	2.04*	-0.03+	0.54*+
Spain	0.68*+	0.70*	0.16*+	0.36*+	0.60*+	0.65*	0.10+	0.12+
Sweden	0.48*+	0.38*+	-0.02+	-0.11+	0.59*+	0.82*	0.04+	0.08+
Switzerland	0.68*+	0.93*	0.07*+	0.17*+	0.59*+	0.82*	0.07+	0.15+
United Kingdom	0.36*+	0.46*+	-0.05+	-0.11+	0.34*+	0.49*+	-0.05+	-0.12+
United States	0.23*+	0.42*+	-0.01+	0.01+	0.25*+	0.59*+	0.01+	0.06+

* (+) Significantly different from 0 (1).

Input-Output (I/O) databases

The Input-Output data for the different countries come from different sources:

- Data for Belgium, Finland, France, Germany, Greece, Italy, Netherlands, Spain, Sweden, and the United Kingdom come from the Eurostat National Accounts database. This database computes the input-output tables for these countries and reports a supply and a use table disaggregated to a total of 59 industries. These 59 industries include 22 manufacturing industries, 5 mining and extraction industries, 3 agriculture industries, 5 construction and energy industries, 8 trade and transport industries, and 17 service industries. We report distribution margin data for 29 manufacturing, mining and agriculture industries (we merge two mining industries into one, given their small production values in most countries).

- Data for Australia on input-output tables come from the Australian Bureau of Statistics. The data reports supply and final use tables for a total of 237 industries. We convert these industries into the CPA classification of 29 manufacturing, mining and agriculture industries.

- Data for the United States on input output tables come from the "Benchmark Input Output Accounts for the US economy" (years 1992, and 1997). The U.S. input output accounts use a specific IO industry classification, which can then be transformed into the NIPA classification (National Income and Product Account Tables) and then aggregated into the CPA classification of 29 manufacturing, mining and agriculture industries used in the paper.

- Data for New Zealand on input output tables come from Statistics New Zealand. The data report supply, use, and import tables for a total of 210 industries. We aggregate these industries into the CPA classification of 29 manufacturing, mining and agriculture industries.

Calculation of distribution margins:
We compute the distribution margins for total supply in the industry as the ratio of the value of trade and transport margins to the value of total supply in the industry at purchasers' prices. Purchaser prices include the cost of supply at basic prices plus the distribution (retail, wholesale and transportation) costs plus net taxes on products. To the extent that taxation differs significantly across countries for the same industry and across industries within a country, distribution margins may not be perfectly comparable in all cases.

Calculation of imported input ratios:
The Input Output tables report the value of the use matrix breaking down the use of inputs by origin: domestic and imported. We calculate imported inputs into the production of each industry as the ratio between the total value of imported intermediate inputs by an industry to the value of total intermediate inputs.

Techniques to construct the imported intermediate flows matrix in the input-output tables vary by country. Most countries used to some extent the import proportionality assumption. This technique assumes that an industry uses an import of a particular product in proportion to its total use of that product. This assumption is limiting since some industries might be using inputs from domestic and import sources in different proportions than the average of the economy. Countries made use of this assumption at very different levels of aggregation. For instance, the OECD reports that Germany and Denmark made use of over 2000 different commodities, while the U.S. and Japan used slightly over 500 and the United Kingdom less than 200.

Calculation of share of tradables in consumption:
This number is the ratio of the value at purchaser prices of consumption by households in tradable products relative to the value of total consumption by households. Tradable products are defined as the set of 29 manufacturing, agricultural, and mining industries for which distribution margins have been calculated.

Calculation of imported input share of tradables in consumption:
This number is the ratio of the value at purchaser prices of imported inputs used in the production of the industries consumed by households in tradable products relative to the value of total consumption by households of those same products. Tradable products are defined as

the set of 29 manufacturing, agricultural, and mining industries for which distribution margins have been calculated.

Calculation of imported input share of nontradables in consumption:
This number is the ratio of the value at purchaser prices of imported inputs used in the production of nontradable products consumed by households relative to the value of total consumption by households of those same products. Nontradable products are those included in the construction, energy and services industries.

Appendix Table 1. Imported Inputs in Other Industries (Average Percent Share)

e40	Electricity, gas, steam and hot water supply	27.82
e41	Collection, purification and distribution of water	13.21
f45	Construction	18.24
g50	Sale, maintenance and repair of motor vehicles	24.58
g51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	16.17
g52	Retail trade, except of motor vehicles, motorcycles; repair of personal&household goods	11.72
h55	Hotels and restaurants	14.92
i60	Land transport; transport via pipelines	18.07
i61	Water transport	40.61
i62	Air transport	34.50
i63	Supporting and auxiliary transport activities; activities of travel agencies	17.96
i64	Post and telecommunications	21.55
j65	Financial intermediation, except insurance and pension funding	13.30
j66	Insurance and pension funding, except compulsory social security	13.43
j67	Activities auxiliary to financial intermediation	9.23
k70	Real estate activities	7.05
k71	Renting of machinery and equipment without operator and personal&household goods	16.65
k72	Computer and related activities	19.62
k73	Research and development	20.94
k74	Other business activities	17.40
l75	Public administration and defense; compulsory social security	15.09
m80	Education	10.48
n85	Health and social work	18.89
o90	Sewage and refuse disposal, sanitation and similar activities	9.43
o91	Activities of membership organization n.e.c.	11.55
o92	Recreational, cultural and sporting activities	16.45
o93	Other service activities	18.30

* Product names given with CPA Codes (Classification of Products by Activity). Imported Input share is calculated as the average of the imported input share for each industry for Austria, Belgium, France, Finland, Germany Hungary, Ireland, Italy, Netherlands, Norway, Poland Portugal, Sweden, Spain and the United Kingdom. N.e.c. not elsewhere classified.

Appendix Table 2. OECD Industry Classification, with SIC mapping

OECD Industry	SIC Classification	Description
1	01-05	AGRICULTURE, HUNTING, FORESTRY AND FISHING
2	10-14	MINING AND QUARRYING
3	15-16	FOOD PRODUCTS, BEVERAGES AND TOBACCO
4	17-19	TEXTILES, TEXTILE PRODUCTS, LEATHER AND FOOTWEAR
5	20	WOOD AND PRODUCTS OF WOOD AND CORK
6	21-22	PULP, PAPER, PAPER PRODUCTS, PRINTING AND PUBLISHING
7	23	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL
8	24ex2423	CHEMICALS EXCLUDING PHARMACEUTICALS
9	2423	PHARMACEUTICALS
10	25	RUBBER AND PLASTIC PRODUCTS
11	26	OTHER NON-METALLIC MINERAL PRODUCTS
12	271+2731	IRON & STEEL
13	272+2732	NON-FERROUS METALS
14	28	FABRICATED METAL PRODUCTS, EXCEPT MACHINERY & EQUIPMENT
15	29	MACHINERY AND EQUIPMENT, N.E.C.
16	30	OFFICE, ACCOUNTING AND COMPUTING MACHINERY
17	31	ELECTRICAL MACHINERY AND APPARATUS, NEC
18	32	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT
19	33	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS
20	34	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS
21	351	BUILDING AND REPAIRING OF SHIPS AND BOATS
22	353	AIRCRAFT AND SPACECRAFT
23	352+359	RAILROAD EQUIPMENT AND TRANSPORT EQUIPMENT N.E.C.
24	36+37	MANUFACTURING NEC; RECYCLING
25	4	ELECTRICITY, GAS & WATER
26	5	CONSTRUCTION
27	61+62	WHOLESALE & RETAIL TADE
28	63	RESTAURANTS & HOTELS
29	71	TRANSPORT & STORAGE
30	72	COMMUNICATION
31	81+82	FINANCE & INSURANCE
32	83	REAL ESTATE AND BUSINESS SERVICES
33	9	COMMUNITY, SOCIAL & PERSONAL SERVICES
34		PRODUCERS OF GOVERNMENT SERVICES
35		OTHER PRODUCERS
36		STATISTICAL DISCREPANCY