THE SENSITIVITY OF THE CPI TO EXCHANGE RATES: DISTRIBUTION MARGINS, IMPORTED INPUTS, AND TRADE EXPOSURE

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Abstract—This paper quantifies the relative importance of the different channels of CPI responsiveness to exchange rates and import prices across 21 industrialized economies. The paper provides new and rich cross-country and cross-industry details on the sensitivity to exchange rates of distribution margins; the extent of imported inputs use in different categories of consumption goods; and on their role in consumption of nontradables, home-produced tradables, and imported goods. The dominant channel for CPI sensitivity is through the costs arising from imported input use in goods production. This channel is more important than changes in prices of imported goods directly consumed.

I. Introduction

THE implications that globalization trends have for monetary policy are actively debated, as demonstrated by the recent exchanges between Bernanke (2007), Ferrero, Gertler, and Svensson (2010), Woodford (2010), Mishkin (2007), and Rogoff (2007). One aspect of this debate concerns the transmission of exchange rate movements into aggregate consumer prices, as opposed to only into the relative prices of selected traded goods. In this paper, we provide extensive empirical and calibration results to highlight the channels through which exchange rates and import prices are transmitted to consumer price indexes.

We begin by carefully framing what the impulse from exchange rates to Consumer Price Index (CPI) sensitivity is expected to be, given the existence of home and foreign tradable goods and nontradable goods in consumption. We focus attention on the roles that distribution margins and imported inputs used in production have in transmission of the border prices of imports and of exchange rates. For this purpose, we use a CPI aggregator as well as a workhorse two-country model with wage stickiness. Our model is a straightforward variant of Obstfeld and Rogoff (2000), Corsetti and Dedola (2003), and Burstein, Neves, and Rebelo (2003). Our variant has distribution margins, the sensitivity of these margins to exchange rates, imported inputs in the production of tradable and nontradable goods, and the sensitivity of these imported input shares influencing the price elasticities of specific types of consumer goods and the aggregate CPI.

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The existence of a distribution sector reduces the foreign content within imports actually consumed, driving a wedge between border and retail prices. Such expenditures on transportation, storage, finance, insurance, wholesaling, and retailing are 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 indexes. Imperfect competition in the distribution sector can lead to "double marginalization," with distributors absorbing some of the exchange rate fluctuations in order to maintain stable prices or expand market share at the retail level (Hellerstein, 2008).[1] If retailers absorb exchange rate fluctuations in their own margins, then consumers will experience less pass-through than prices at the border (Devereux, Engel, & Tille, 2003; Devereux & Engel, 2002). Our extension to the workhorse model also allows production flexibility, defined as the ability of producers to switch between inputs imported from countries with appreciating currencies and those with prices less sensitive to exchange rates.

The objective of our approach is to quantify the scale of each of these dimensions and provide benchmarks for empirical studies that identify low CPI sensitivity to exchange rates. Our approach has the important advantage of avoiding the observability issue that plagues empirical studies in which the impulse from exchange rates to the CPI of an economy may be difficult to isolate in light of endogenous monetary reactions. For example, Gagnon and Ihrig (2001), Baily (2003), and Bailliu and Fujii (2004) correctly argue that a home currency depreciation may be met with a corresponding monetary tightening given goals of maintaining low and stable inflation. In this case, the estimated exchange rate and CPI sensitivities are low, even while the monetary reaction leads the relative prices of traded and nontraded goods to diverge in the aftermath of an exchange rate shock: the depreciation raises the price of traded goods while the monetary contraction reduces the relative price of nontraded goods.

In the course of providing our benchmark calibration results, we generate a range of new empirical facts of broad interest and based on careful analysis of data from 21 OECD countries.[2] Most significant, we document the size of the distribution sector and the degree of imported input use

[1] The complementary approached provided by Bacchetta and van Wincoop (2003) has consumer price insensitivity to exchange rates 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. Corsetti and Dedola (2005) make related arguments in a different production chain and pricing set-up.

[2] This evidence complements and considerably extends the evidence on Argentina and the United States provided by Burstein, Eichenbaum, and Rebelo (2006).

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by country, by industry, and in some cases over time. Since CPI calibrations require distribution margins on consumption goods per se, and not the typically lower distribution margins that pertain to government and investment goods, we carefully separate out the distribution margins in each economy according to sources of final demand. Across countries, distribution margins on household consumption goods are between 30% and 50% of purchasers' prices. While the data we have assembled can only be used to crudely estimate distribution expenditure adjustment in response to exchange rate changes, our tests lend support to the double marginalization hypothesis: distribution expenditures fall when the local currency depreciates and the border prices of imports become more expensive in local currency terms. We also document that imported input use in production is important across countries in both tradable and nontradable goods production. Imported inputs account for between 10% and 48% of the final price of tradable goods and are used less extensively in nontradables production, ranging from 3% of production costs in the United States to 22% in Hungary.

Our main quantitative results show that the CPI can be significantly influenced by price movements at the border, including those caused by exchange rate movements. Transmission is through tradables goods in the economy—both tradables that directly appear in consumption and tradables that are embedded in imported inputs used in the production of nontraded and home tradable goods. While 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 that they can play a role in magnifying pass-through into consumption prices. Specifically, distribution expenditures for all tradable and nontradable goods consumed are sensitive to exchange rates, since nontradable sector, which provides distribution services, relies on imported productive inputs. Thus, imported inputs matter for both the prices of directly consumed nontradable goods and the prices of tradable goods in the final consumption baskets of economies. Our calibration exercises show that substantial cross-country heterogeneity in the transmission of international shocks should be expected.

Moreover, the importance of specific transmission channels is quite different across countries. Interestingly, the dominant channel for transmission in OECD countries is through the use of imported components in domestic production instead of through direct household consumption of imported goods. We also show the importance for pass-through of economic flexibility. Calibrated price effects of exchange rates and import prices are smaller when economies can more flexibly substitute away from imported components into domestic components when producers are confronted with an adverse cost shock.

Section II presents our basic modeling approach, beginning with a price aggregator and then presenting the model of pass-through into respective price indexes, with particular attention paid to the roles of distribution and imported inputs. Section III presents the evidence required for calibrating the model across countries, specifically focusing on distribution margins, imported inputs, and trade shares across countries, industries, and time. Section IV provides the calibration results across the OECD and explores the key channels for transmission of exchange rate and import prices into CPIs. Section V concludes.

II. A Model of Pass-Through into Consumer Prices

A. *The Price Aggregators*

For formalizing the channels for exchange rate transmission into the CPI, we start with a workhorse two-country model with wage stickiness, as in Obstfeld and Rogoff (2000) and Corsetti and Dedola (2003). These models provide a utility-based framework, with CES utility function over nontraded and traded goods consumption, with each type of good comprising a continuum of varieties facing similar elasticities of substitution, θ. Consumption of tradable (T) and nontradable (N) products is also governed by a constant elasticity of substitution ϕ.

The CES price aggregator resulting from these models is $P_t = [\alpha P_t(T)^{1-\phi} + (1-\alpha) P_t(N)^{1-\phi}]^{1/1-\phi}$, where $P_t(T)$ and $P_t(N)$ are price aggregators for tradable and nontradable products, respectively, and α is the consumption weight on tradable products.

Pass-through of exchange rates into the aggregate CPI (the elasticity of CPI to changes in nominal exchange rates) is given by

$$\eta^{P_t,e_t} = \alpha\left(\frac{P_t(T)}{P_t}\right)^{1-\phi}\eta^{P_t(T),e_t} + (1-\alpha)\left(\frac{P_t(N)}{P_t}\right)^{1-\phi}\eta^{P_t(N),e_t}, \tag{1}$$

where $\eta^{j,e}$ refers to the elasticity of price j with respect to the nominal exchange rate e.

Given the CES utility structure, prices of tradable goods are subject to a similar aggregator, with ϕ_T the substitution elasticity between domestically produced and foreign-produced tradable products, denoted by H and F, respectively; α_T is the consumption weight of domestically produced tradable products within all tradable products. Expanding equation (1) to include the tradable goods aggregator, the resulting CPI elasticity with respect to exchange rates becomes

$$\begin{aligned}\eta^{P_t,e_t} = {}& \alpha\left(\frac{P_t(T)}{P_t}\right)^{1-\phi}\alpha_T\left(\frac{P_t(H)}{P_t(T)}\right)^{1-\phi_T}\eta^{P_t(H),e_t} \\ & + \alpha\left(\frac{P_t(T)}{P_t}\right)^{1-\phi}(1-\alpha_T)\left(\frac{P_t(F)}{P_t(T)}\right)^{1-\phi_T}\eta^{P_t(F),e_t} \\ & + (1-\alpha)\left(\frac{P_t(N)}{P_t}\right)^{1-\phi}\eta^{P_t(N),e_t},\end{aligned} \tag{2}$$

where $P_t(H)$ and $P_t(F)$ refer, respectively, to the price indexes of domestic and foreign tradable products.

Aggregate pass-through of exchange rate movements into the CPI is a weighted average of pass-through elasticities into the prices of traded and nontraded aggregates. The relative weights in these two elasticities are state contingent and dependent on elasticities of substitution between tradable (foreign and domestic) and nontradable goods and the equilibrium shares of tradable and nontradable products.

When $\phi = \phi_T$, equation (2) becomes

$$\begin{aligned}\eta^{P_t,e_t} = {} & \alpha \cdot \alpha_T\left(\frac{P_t(H)}{P_t}\right)^{1-\phi}\eta^{P_t(H),e_t} \\ & + \alpha \cdot (1-\alpha_T)\left(\frac{P_t(F)}{P_t}\right)^{1-\phi}\eta^{P_t(F),e_t} \\ & + (1-\alpha)\left(\frac{P_t(N)}{P_t}\right)^{1-\phi}\eta^{P_t(N),e_t}.\end{aligned} \tag{3}$$

Rule-of-thumb discussions sometimes incorrectly focus on the import share in domestic demand as the exclusive transmission channel for exchange rates into aggregate price indexes. There are clearly other forces at work that differentiate across CPI sensitivities to exchange rates. The CPI elasticity also depends on the relative prices between domestic- and foreign-produced goods. These relative prices are a function of relative wages and productivity between home and foreign production. They also depend on the structure of the value-added chain and the degree of domestic and foreign content that goes into each type of good. The domestic value added in foreign tradables, which arises by domestic distribution costs, and the foreign value-added that shows up in domestically produced goods, which arises by imported inputs used in the home production of these goods, affect the final pass-through elasticities.

Because nontraded goods are consumed directly and add local content to both home tradable goods and imported goods, imported inputs used in the production of nontradable goods can have a particularly important effect for the CPI sensitivity to exchange rates. 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 may be when priced in local currency. Overall, exchange rates affect home tradables prices due to the use of imported inputs in the production of these goods. Again, only fully elastic input costs would make this channel insignificant.

Among the other channels for pass-through into the CPI, there is direct transmission into the CPI through the foreign content of the consumption good indexed by F, that is, the total value of this consumption good less the expenditure on domestic distribution costs. The strength of this channel can be moderated if the expenditure on distribution changes when the exchange rate moves, that is, if double marginalization occurs. Finally, there also is a possibility that distributors change the margins charged on home tradable goods H when they observe competing imports having price changes attributable to exchange rates.

B. A Two-Country Model of the Exchange Rate Pass-Through

To elaborate further on the features underlying each of the price elasticities in equation (3), we appeal to a workhorse model of pricing of goods within the H, F, and N indexes. We introduce two simple extensions to this workhorse model to generate additional realism in price sensitivity to exchange rates: distribution costs and imported inputs in the production of domestic products.

Introducing expenditures on distribution. On the supply side, the marginal cost of production of tradable products 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 et al. (2003), and Corsetti and Dedola (2003), we assume that bringing one unit of a traded good to consumers requires units of a basket of differentiated nontraded goods indexed by N.[3] 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. The individual brands within home tradables, foreign tradables, and nontradables are indicated by the lowercase letters h, f, and n.

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

$$P_t(h) = \bar{P}_t(h) + m_t(h{:}e_t)\,P_t(N), \tag{4}$$

where $P_t(N)$ is the corresponding utility-based price index for nontradable products and $m_t(h{:}e_t)$ are the distribution service inputs required per unit of output of brand h. This specification attributes the failure of purchasing power parity across countries, at least in part, to the presence of local transaction and distribution costs, which are direct contributors to the purchaser prices $P_t(h)$, as argued by Obstfeld and Rogoff (2000). Analogous notation is used for imported goods, with brands indexed by f.[4] Nontraded goods, with brands indexed by n, are assumed to be exempt from these added costs from their own sector.

[3] It is assumed that all traded goods use the same bundle of distribution inputs.

[4] Given the CES 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.

Terms like $m_t(\cdot) \cdot P_t(N)$ are found in Corsetti and Dedola (2003) and Burstein et al. (2003), where distribution costs drive a wedge between border and consumption prices on imports. Other studies consider imports more as intermediate goods that are repriced or combined with local content by distributors (or home final goods producers). Devereux et al. (2003) and Devereux and Engel (2002) gave the distributor power to reprice 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 repricing, 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.[5]

In our specification of distribution costs in equation (4), we introduce the exchange rate as an argument of the distributor margin $m_t(i{:}e)$, where $i \in (h, n)$. Including this relationship allows for possible deviations in the empirical analysis from the competitive distribution sector. Our specification is intended to be general enough to permit a fixed distribution margin in the face of currency fluctuations or permit large margin responses if particular assumptions on industrial structure would warrant this.[6]

Introducing imported productive inputs. Our second extension to the standard approach is that we allow for the use of imported productive inputs, thereby introducing a direct channel through which exchange rate changes influence domestic producer marginal costs.[7] We suppose that per unit production requires imported input share $\mu_t(h{:}e_t)$ on home tradable brands and $\mu_t(n{:}e_t)$ on home nontradable brands. The pricing equations for home nontradable brands n, home tradable brands h, and imported consumption brands f are given by

$$P_t(n) = \frac{\theta}{\theta - 1}\, c_t(n) = \frac{\theta}{\theta - 1}\left[Z_N + \mu_t(n{:}e_t)\, Z_F\right] \tag{5}$$

$$\begin{aligned} P_t(h) &= \frac{\theta}{\theta - 1}\, c_t(h) \\ &= \frac{\theta}{\theta - 1}\left[Z_H + m_t(h{:}e_t) \cdot P_t(N) + \mu_t(h{:}e_t)\, Z_F\right] \end{aligned} \tag{6}$$

$$\begin{aligned} P_t(f) &= \frac{\theta}{\theta - 1}\, e_t c_t{*}(f) \\ &= \frac{\theta}{\theta - 1}\left[Z_F + m_t(f{:}e_t) \cdot P_t(N)\right], \end{aligned} \tag{7}$$

where the Z terms refer to effective wages (i.e., wages per unit of productivity) in the respective sectors. The effective foreign wage Z_F is expressed in terms of the home currency and refers to the cost in home currency of producing one unit of the imported product.

This derivation assumes that all distribution costs are incurred in the home market, and productivity parameters as well as domestic and foreign wages are sticky over the relevant pricing horizon. The derivation also assumes that nontradable products do not require distribution costs for their production. This is the standard assumption followed in national income accounting and also applies to our data. The imported input shares $\mu_t(i{:}e)$ for $i \in (h, f)$ also are functions of e, the exchange rate, defined as the domestic currency price of foreign exchange.[8] This treatment leaves open the possibility that producers can substitute away from higher-priced imported inputs in the aftermath of domestic currency depreciation.

We differentiate equations (5) through (7) to derive home tradable, home nontradable, and imported goods price elasticities, or pass-through rates, with respect to exchange rates:

$$\begin{aligned} \eta^{P_t(n),e_t} &= \frac{\partial P_t(n)/\partial e_t}{P_t(n)/e_t} = (1 + \eta^{u_t(n:e_t),e_t})\left[\frac{\mu_t(n{:}e_t)\, Z_F}{c_t(n)}\right] \\ &= \frac{\theta}{\theta - 1}\,(1 + \eta^{u_t(n:e_t),e_t})\left[\frac{\mu_t(n{:}e_t)\, Z_F}{P_t(n)}\right] \end{aligned} \tag{8}$$

$$\eta^{P_t(h),e_t} = \frac{\partial P_t(h)/\partial e_t}{P_t(h)/e_t} = \frac{\theta}{\theta - 1}\left[\begin{aligned} &(\eta^{P_t(N),e_t} + \eta^{m(h),e_t})\,\frac{m(h{:}e_t)\, P_t(N)}{P_t(h)} \\ &+ (1 + \eta^{u_t(h:e),e_t})\,\frac{\mu_t(h{:}e_t) Z_F}{P_t(h)} \end{aligned}\right] \tag{9}$$

[5] By contrast, Burstein, Neves, and Rebelo (2003), following Erceg and Levin (1995), 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.

[6] 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 put forth early by Froot and Klemperer (1989).

[7] The assumed short-run rigidity of wages to real exchange rates is supported by empirical analyses (Campa & Goldberg, 2001; Goldberg & Tracy, 2003), except for some less-skilled workers at the time they change jobs.

[8] This specification, which follows Corsetti and Dedola (2003), implies that the markup on the final price also gets 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.

$$\eta^{P_t(f),e_t} = \frac{\partial P_t(f)/\partial e_t}{P_t(f)/e_t} \tag{10}$$
$$= 1 - \frac{\theta}{\theta - 1} \frac{(m_t(f{:}e_t)P_t(N))}{P_t(f)} [1 - (\eta^{m(f{:}e_t),e_t} + \eta^{P_t(N),e_t})].$$

In equation (8), the necessary condition for nontraded brand prices to be sensitive to exchange rates is that producers use imported inputs, which is the only channel we have introduced for cost sensitivity to exchange rates. 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, as captured by $\eta^{\mu_t(n:e_t),e_t} < 0$.

Equation (9) 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 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 (10) is typically the focal point of studies of the sensitivity of foreign goods prices to exchange rates. Note, however, that this specification gives consumption price sensitivity to exchange rates, not border price sensitivity. 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 is the pass-through of exchange rate or border price movements. Conceptually, for each sector, the goods price indexes are an aggregate of the individual brand prices. The aggregate elasticities, $\eta^{P_t(N),e_t}$, $\eta^{P_t(H),e_t}$, and $\eta^{P_t(F),e_t}$, are a weighted average of the elasticities over respective component brands.

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

Aggregated equations (8) through (10), combined with equation (3), provide the necessary structure for calibrating price sensitivity to exchange rate and import price shocks. In this section we provide background on those parameters for which we have prior information and then turn to extensive cross-country information on other parameters. The main contribution of this section is the empirical evidence on distribution margins and imported inputs into production, looking across 21 countries, broken down into approximately thirty industries within each country. Our measures are consistently estimated across countries and have a relatively large degree of comparability.

The evidence on the size of distribution margins is limited. Burstein et al. (2003) provide evidence on the size of distribution margins using data for two countries, the United States and Argentina, concluding that local distribution services (for example, expenditures on transport, wholesale and retail services, marketing) 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 United States, 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).

A. *Data and Measurement Issues of Imported Inputs and Distribution Margins*

To compute the measures of imported input and distribution margins, we start with input-output tables and three different kinds of prices that 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

TABLE 1.—DISTRIBUTION MARGINS, BY PURCHASERS PRICES AND BY SOURCES OF FINAL DEMAND

		Distribution Margins across Sectors			Household Consumption			Fixed Capital Consumption			Export		
Country	Year	Average	Maximum	Minimum	Wholesale-Retail	Transport	Total	Wholesale-Retail	Transport	Total	Wholesale-Retail	Transport	Total
Australia	2000/01	21.4	54.1	3.6									
Austria	2000	15.6	34.6	0.0	36.08	8.76	44.84	17.57	0.59	18.16	6.71	3.38	10.09
Belgium	2000	13.8	34.9	2.5	29.24	5.41	34.65	15.91	0.42	16.34	7.16	3.99	11.14
Denmark	2000	16.0	35.8	2.5	40.15	6.05	46.20	17.18	0.21	17.39	10.51	19.08	29.58
Estonia	1997	12.1	25.9	3.4	24.15	7.64	31.79	7.16	0.51	7.66	5.85	14.91	20.77
Finland	2002	13.2	35.5	3.1	41.80	8.35	50.15	3.38	0.22	3.60	0.62	3.76	4.38
France	2000	19.4	62.3	1.0	27.26	6.24	33.50	7.96	1.39	9.35	3.20	5.24	8.44
Germany	2000	15.1	42.4	3.6	33.00	7.30	40.30	5.60	2.16	7.76	5.26	4.19	9.46
Greece	1998	19.6	46.8	0.4	31.02	6.50	37.52	13.60	0.00	13.60	13.44	13.75	27.19
Hungary	2000	8.4	23.8	0.4	30.60	6.87	37.47	10.53	0.00	10.53	2.24	2.70	4.94
Ireland	1998	9.5	27.0	0.0	26.30	8.30	34.61				5.11	1.49	6.60
Italy	2000	18.4	45.2	3.7	34.78	7.19	41.97	8.90	3.53	12.43	4.76	7.08	11.84
Netherlands	2001	14.6	36.5	0.0	41.80	8.35	50.15	3.38	0.22	3.60	0.62	3.76	4.38
New Zealand	1995/96	13.9	32.3	0.0	31.23	9.76	40.99	14.87	0.00	14.87	5.51	11.70	17.21
Norway	2002	16.6	4.6	3.2	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	14.8	28.8	0.0	30.59	2.49	33.08	15.70	0.00	15.70	1.55	5.91	7.46
Spain	1995	18.1	75.5	0.1	32.01	5.84	37.84	3.17	0.63	3.80	5.77	5.69	11.46
Sweden	2001	15.4	35.8	1.0	32.34	2.93	35.26	10.72	0.17	10.89	1.26	4.50	5.76
United Kingdom	1995	20.7	46.1	0.0	40.89	7.80	48.69	5.76	1.42	7.19	8.49	5.18	13.67
United States	1997	23.9	70.4	4.7	40.93	1.82	42.75	13.88	1.58	15.46	9.46	3.06	12.53

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, and other taxes.

We compute purchaser's prices margins: the expenditures on distribution margins plus transportation taken relative to total supply valued at purchaser's prices. Total supply valued at purchaser prices includes the value of production at producer prices plus the value of the distribution margins and net taxes on production and products. The alternative would be to compute basic prices margins, for which supply is valued at basic prices. Conceptually the basic margins are more similar to supplier calculations, while the purchaser's margins are closer to calculations on the basis of consumer prices. The literature has traditionally used margins measured relative to purchaser's 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 the appendix.

B. *The Size of Country and Industry Distribution Margins*

We measure distribution margins for 29 manufacturing and primary industry groupings for the countries listed in the first column of table 1. We provide some of this decomposition information in the first three data columns and also consider the size of these distribution margins from the vantage point of countries rather than industries. (Table A1 presents a similar table with information across industries.) In order to construct these country margins for each country, we sum over the distribution margins for all industries that report positive distribution margins. We calculate aggregate distribution margins that are on the order of 15% to 25% of output for the industries in this industrialized country sample. 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. 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.

By examining the range of values for the distribution margins relative to purchasers' prices across countries and for these 29 industries (unweighted by country or industry size), 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, as well as in wearing apparel and furs, tobacco products, and fish and fishing products. Margins appear to be lowest on some commodity-type products and industries, such as petroleum and natural gas, ores and mining products, and basic metals.

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, the last nine columns of table 1 present 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.

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 (expecting 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 seven out of nineteen 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.

Distribution margins include the sum of wholesale-retail margins and transportation costs. The wholesale and retail components dominate distribution costs in almost all industries 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.

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. The transport margin in exports is larger than the wholesale-retail margin for eleven countries in the sample. 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 from the input-output tables. The imported input measures calculated for the same set of industries for which we have calculated distribution margins (for 29 homogeneous manufacturing and primary-industry groupings) show that 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 2 reports the average imported inputs into production for all industries. This measure includes the 29 industries and 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 and 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 they refer to only 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 last two columns of table 2 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.[9] Tradables' use of imported components ranges from 10% of total costs in the United States (in 1997, prior to the late 1990s acceleration of internationally integrated production) up to 49% of Ireland. While calibrations usually treat nontraded goods production as using only domestic inputs, the data show that the share of 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%.

The role of imported inputs differs substantially between manufacturing industries and other industries. We already

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

TABLE 2.—IMPORTED INPUT SHARES, IMPORT SHARES IN TRADABLES, AND TRADABLES IN CONSUMPTION

Country	I-O Year	Imported Inputs in Total Inputs	Imports to Tradables $1 - \alpha_T$	Tradables to Consumption α	Imported Inputs Relative to Costs in Tradable Production $\mu(H{:}e_t)$	Imported Inputs Relative to Costs in Nontradables $\mu(N{:}e_t)$
Australia[a,b]	2000/01		0.27	0.31	0.18	0.09
Austria	2000	0.294	0.59	0.33	0.43	0.15
Belgium	2000	0.317	0.55	0.34	0.48	0.15
Denmark	2000	0.255	0.59	0.28	0.33	0.10
Estonia	1997	0.395	0.57	0.59	0.42	0.22
Finland	2002	0.229	0.42	0.26	0.29	0.10
France	2000	0.141	0.24	0.38	0.20	0.08
Germany	2000	0.214	0.33	0.36	0.27	0.09
Greece	1998		0.57	0.39	NA	NA
Hungary[a]	2000	0.335	0.34	0.43	0.41	0.22
Ireland	1998	0.485	0.47	0.41	0.49	0.35
Italy	2000	0.185	0.26	0.40	0.24	0.09
Netherlands	2001	0.30	0.57	0.26	0.41	0.14
New Zealand[a]	1995/96		0.31	0.38	0.27	0.07
Norway	2002	0.222	0.46	0.34	0.25	0.14
Poland	2000	0.190	0.25	0.47	0.24	0.07
Portugal	1999	0.229	0.45	0.42	0.37	0.14
Spain	1995	0.175	0.25	0.35	0.22	0.08
Sweden	2000	0.261	0.47	0.26	0.35	0.16
United Kingdom	1995	0.202	0.34	0.34	0.25	0.10
United States	1997	0.082	0.20	0.25	0.10	0.03

[a] 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.
[b] For Australia, the ratio of imported inputs in the production of tradables and nontradables refers to 1994/95 I-O benchmark tables from the OECD.

discussed that manufacturing industries have a much larger share of imported inputs than Agriculture and Mining. Imported inputs have a large share of costs of production, mainly in industries with a large consumption of energy products as raw materials. These industries include non-manufacturing industries such as 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 nonmanufacturing industries, imported inputs play a minor role, with ratios almost always below 20% of production costs.

E. *Consumption, Trade Shares, and Distribution Margin Elasticities*

The calibration work on exchange rate consequences for country CPIs requires values for the demand elasticity (θ), elasticity of substitution among groups of products (ϕ), and elasticities of response to exchange rates of distribution margins and imported inputs.[10] 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 (2002) find markups for U.S. 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 14.

We estimate the elasticities of distribution margins to exchange rates from the available data on distribution margins. A number of countries in our panel have multiple years of margin data that can be used for time-series panel construction. The availability of these data is limited to only eight countries in the data set. 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 available data do not distinguish between markups for foreign versus domestic producers, nor do they distinguish margins by different components of final demand.

The panel regression specification we use is given by equation (11),

$$\Delta m_t^c(\cdot{:}e_t) = \beta_t + \beta_c + \beta_c \Delta X_t^c + \varepsilon_t, \tag{11}$$

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 3 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. Across countries, even with the shortcomings of the aggregate data described above, we find that home currency depreciations are associated with lower distribution margins. This effect is statistically significant when the real exchange rate is used, and it is very robust to the inclusion of country or time effects. A 1% real depreciation of the real

[10] The calibrations basically shut down the role of initial conditions and substitution between tradables and nontradables 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).

TABLE 3.—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^2	0.06	0.14	0.17	0.18	0.24	0.27
Number of observations	37	37	37	37	37	37

Note: The dependent variable is the distribution margin for final demand for the following countries: Belgium, Denmark, France, Germany, Italy, Spain, UK, and United States for the period 1995 to 2001, except for the United States, 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.

exchange rate results in a 0.47% decrease in distribution margins. The correlation between nominal exchange rates and distribution margins is also negative, although statistically significant only in specifications that exclude fixed effects.

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, 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. However, this is not a first-order concern because most industries have the majority of their distribution costs associated with the wholesale and retail components. Second, the distribution data used aggregate 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 are unable to disentangle $\eta^{m_t(h:e_t),e_t}$ from $\eta^{m_t(f:e_t),e_t}$. To the extent, that local currency pricing takes place, distribution margins in imported products are more likely to be sensitive to exchange rates than distribution margins in domestically produced products.

More compelling numerical estimates of actual distribution expenditure for $\eta^{m_t(h:e_t),e_t}$ and $\eta^{m_t(f:e_t),e_t}$ are starting to be available from detailed producer and industry studies, as opposed to the aggregate industry data of our sample. Wholesale and retail prices for specific goods in the beer industry show that retailers and producers share the burden of profit adjustment in response to exchange rate fluctuations (Hellerstein, 2008). 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. In the beer market in the United States, 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. For import-competing domestic brands (light beers), the retail margins decrease by 0.20%. In the automobile industry, the margins on domestic brands that are not close substitutes for imported brands rise by roughly 0.10% following a 1% dollar depreciation (Hellerstein & Villas-Boas, 2006).

Given this evidence, in most of our calibration exercises, we assume values for $\eta^{m_t(f:e_t),e_t}$ that fall between 0 and −0.50; in response to a 1% home currency depreciation, distributors can either leave distribution expenditures margins on home tradables unchanged, $\eta^{m_t(h:e_t),e_t} = 0$, or lower distribution margins by half.[11] We assume imported input share elasticities to exchange rates of either 0 or −0.10, so that the fraction of production inputs attributed to imported components is either unchanged or declines by 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%. Assumptions made along this dimension have significant consequences for the calibration results. Given that flexibility of economies is viewed as one of the essential differences that determine the consequences of different types of shocks, we explore the full range of margin and production flexibility options to demonstrate that this "flexibility" dimension can yield large differences across countries in terms of insulation or magnification of globalization effects on prices.

IV. Calibration of Price Elasticities with Respect to Exchange Rates

Given the extensive data we have computed across countries for imported inputs, distribution margins, and trade exposures, we now conduct calibration exercises to generate quantitatively sound sensitivities of different types of prices to (exogenous) exchange rate or import price movements. We also decompose the sources of sensitivities and provide

[11] 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 4.—CALIBRATED PRICE ELASTICITIES WITH RESPECT TO EXCHANGE RATES

	$\eta^{P_t(N:e_t),e_t}$ Nontraded Goods Prices		$\eta^{P_t(H:e_t),e_t}$ Home Tradable Prices		$\eta^{P_t(F:e_t),e_t}$ Imported Goods Prices			
	$\theta = 4$	$\theta = 10$	$\theta = 4$	$\theta = 10$	$\theta = 4$		$\theta = 10$	
					$\eta^{m_t(f:e_t),e_t} = 0$	$\eta^{m_t(f:e_t),e_t} = -0.5$	$\eta^{m_t(f:e_t),e_t} = 0$	$\eta^{m_t(f:e_t),e_t} = -0.5$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
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
United 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 $\mu(h:e) = 0.40$, $\mu(n:e) = 0.15$; Australia: assumes the distribution margin shares of New Zealand. The share of imported inputs in production does not change with exchange rate changes; the elasticities on home tradables' distribution margins are 0; and normalizes $Zi = 1$.

interpretations of the key drivers of the effects of globalization on these elasticities. As a start, table 4 reports our model's base case predictions for each component index for each country. These elasticities are all derived under the monopolistic competition structure and are essentially the response of domestic price indexes to changing border prices of imports, whether or not these border price movements are driven by exchange rates. The first two data columns of table 4 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, which studies value between 4 and 10. The next two columns provide calibrated exchange rate pass-through into home tradables' prices. The final four columns report the sensitivity to exchange rates of the consumption prices of imported goods, under alternative assumptions about demand elasticities and about whether distribution expenditures are elastic with respect to exchange rates, absorbing some of the movements in margins.

A number of interesting observations emerge from this table. First, elasticities of demand have substantial implications for pass-through into price aggregates. Comparisons of columns 1 with 2 and columns 3 with 4 show that lower demand elasticities, which lead to higher producer markups, also generate stronger pass-through of border price changes into the consumption prices of each type of good. Second, there are substantial cross-country differences in base-case price sensitivities for nontraded goods. These differences are closely tied to differences in producer reliance on imported inputs into their production processes, since many other calibration parameters are held identical across countries at this point. When imported input costs rise, there is more extensive pass-through into prices of nontradable and also home tradable goods. Since we observed that home tradables' producers tend to rely more heavily on imported inputs than nontradables' producers do, the resulting exchange rate pass-through into home tradables is higher (comparison of columns 1 and 3).

The table clearly shows that even without introducing the dimension of differences across countries in pass-through of exchange rates into import prices, we observe much lower pass-through of import prices into the United States. This result is mainly due to lower use of imported inputs into domestic production in the United States relative to elsewhere. For example, the 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 4 focus on pass-through into the consumption prices of imported goods: prices including distribution costs in local currency. Columns 5 and 7 report estimates for the scenario in which distribution expenditures do not adjust in response to exchange rate changes. Observe that differences across countries in pass-through into the consumption prices of imported goods are driven by the sizes of the distribution sectors relative to the purchaser price of the imported products. Our evidence on

TABLE 5.—CPI SENSITIVITY TO IMPORT PRICES, WITH DECOMPOSITION OF SOURCES

	Base Case			Assuming Zero Distribution Costs		
	CPI Elasticity (1)	Percentage due to Imported Inputs (2)	Percentage due to Consumption of Imports (3)	CPI Elasticity (4)	Percentage due to Imported Inputs (5)	Percentage due to Consumption of Imports (6)
Australia	0.17	75	25	0.22	62	38
Austria	0.30	65	35	0.41	52	48
Belgium	0.33	64	36	0.42	56	44
Denmark	0.21	64	36	0.31	47	53
Estonia	0.49	51	49	0.60	44	56
Finland	0.19	75	25	0.27	59	41
France	0.19	71	29	0.23	61	39
Germany	0.21	70	30	0.29	59	41
Greece	0.33	59	41	0.44	48	52
Hungary	0.40	77	23	0.47	69	31
Ireland	0.56	74	26	0.61	68	32
Italy	0.20	73	27	0.27	61	39
Netherlands	0.26	73	27	0.35	57	43
New Zealand	0.19	68	32	0.27	56	44
Norway	0.27	67	33	0.34	54	46
Poland	0.22	66	34	0.28	58	42
Portugal	0.33	62	38	0.41	54	46
Spain	0.18	73	27	0.24	62	38
Sweden	0.29	74	26	0.35	65	35
United Kingdom	0.20	75	25	0.28	59	41
United States	0.07	69	31	0.11	53	47

Note: See table 4 assumptions.

the size of distribution in consumption expenditures shows that pass-through elasticities decline by 30% to 50% relative to the values at the border, leading to elasticities that range between 0.5 and 0.7 across countries. A distribution sector with local costs drives a large wedge between complete pass-through and the calibrated pass-through for imported goods prices. If we then add a further dimension of local flexibility, whereby distribution costs react to exchange rates, lowering markups when the home currency depreciates, the resulting consumption price sensitivity of imports falls further (columns 6 and 8). Overall, border price pass-through into the consumption prices of imported goods is lowest for countries with high distribution shares, as is the case for the Netherlands, Finland, and the United Kingdom, when distribution expenditure margins are adjusted to offset the effects of exchange rates $\eta^{m(f;e_t),e_t} = -0.50$ (instead of $= 0$).

While table 4 has allowed for differences in demand elasticities and for some insights into the effects of flexibility in distribution costs, table 5 explores the effects on the overall consumer price index. Aggregating over the component price elasticities using trade shares, as in equation (3), we generate column 1. This CPI sensitivity to border price changes is computed under the assumption of $\theta = 4$ and assuming no double marginalization or production flexibility. Based on country trade weights and the component elasticities reported in table 4, we calibrate CPI sensitivity to import prices at the border to range from 0.07% for the United States up to 0.56% for Ireland. These calibrated elasticities imply that a 1% increase in the price at the border for U.S. imports will raise the U.S. CPI by 0.07 percentage points. By contrast, a similar import price rise will elevate the Irish CPI by 0.56 percentage points and, on average, by 0.26 percentage points across the 21 countries.

It is informative to decompose the sources of this price sensitivity. Across countries and under the assumptions of the base case scenario, according to columns 2 and 3, about two-thirds of the CPI sensitivity currently arises from internationally integrated production processes (use of imported inputs), while only one-third of the CPI sensitivity is associated with direct consumption of imported goods. While the breakdown varies somewhat across countries, production integration always accounts for at least half of the CPI elasticity.

The role of distribution expenditure in CPI sensitivities, explicitly arising from local content that is added to all consumption goods from domestic shipping, wholesale, retail and advertising costs, is addressed in table 5. Comparison of column 4 with column 1 shows that local distribution expenditures tend to reduce CPI sensitivities by, on average, one-third. For the United States, which is characterized by a relatively high share of distribution expenditures, CPI sensitivity is 36% lower than what it otherwise would have been if these distribution expenditures had been absent. For other countries, columns 5 and 6 of the table show that absent distribution expenditures, imports of consumption goods would account for a substantially higher part of the overall CPI sensitivity.

Finally, we find that an important component of price reaction to import price movements is the degree of economic flexibility of producers, often discussed as being fundamentally different across economies. Our calibration

TABLE 6.—U.S. EXCHANGE RATE PASS-THROUGH ELASTICITIES, UNDER ALTERNATIVE ASSUMPTIONS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Assumptions							
$\eta^{\mu(n:e_t),e_t} = \eta^{\mu(h:e_t),e_t}$	0	0.00	0.00	0.00	−0.10	−0.10	−0.10
$\eta^{m(h:e_t),e_t}$	0	0.00	0.10	0.10	0.00	0.10	0.10
$\eta^{m(f:e_t),e_t}$	0	−0.50	0.00	−0.50	−0.50	0.00	−0.50
Results							
$\eta^{P_t(N),e_t}$	0.040	0.040	0.040	0.040	0.036	0.036	0.036
$\eta^{P_t(H),e_t}$	0.156	0.156	0.213	0.213	0.141	0.198	0.198
$\eta^{P_t(F),e_t}$	0.453	0.168	0.453	0.168	0.165	0.450	0.165
η^{P_t,e_t}	0.084	0.070	0.095	0.081	0.063	0.089	0.075

exercise focuses on two potential types of flexibility, through production adjustments in imported input use and through the response in expenditure on distribution services when the imported goods prices or exchange rate moves. When distribution expenditure on imported goods is sensitive to exchange rates, consumption prices of imported goods respond less to border import price or exchange rate movements. If this force is strong enough, and absent imported inputs for the nontraded sector, exchange rate pass-through into the consumer prices of imported goods could resemble local currency pricing, as in Devereux and Engel (2002). 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. The other key flexibility force is through substitutability between sources of production inputs. If producers have the option of substituting out of some imported inputs and using alternatives that are less sensitive to the import price or exchange rate movement, pass-through into nontraded goods' prices and home tradables' prices declines. This particular channel 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.

These flexibility channels can be of first-order quantitative importance. To show this point, we explore the consequences for calibrated price sensitivities of the United States under alternative assumptions on imported input and distribution expenditure flexibility with respect to exchange rates. The top panel in table 6 provides alternative parameter values for calibrations, and the bottom panel shows resulting patterns of elasticities of prices of different types of consumption goods (nontraded, home tradables, imported, and the aggregate CPI). Comparison across columns of the lower panel shows that most of the differences in the sensitivity of imported goods consumption prices to border price moves come from altering the assumptions on the elasticity of distribution expenditures. By contrast, all of the effect on nontradables comes from altering assumptions on production flexibility, or the ability of producers to substitute away from the imported inputs into domestic inputs.

Finally, we perform a more detailed evaluation of the contributions of these two forms of flexibility across a broader set of parameters values than those reported in table 6. Focusing again on the United States, we allow the sensitivity of both imported inputs and the elasticity of distribution costs to import price changes $\eta^{\mu(h:e_t),e_t}$ to be negative and to range between 0 and -1. Using all calibration parameters, the resulting CPI elasticity to import prices is $\eta^{P_t,e_t} = 0.0838 + 0.0624\eta^{\mu(h:e_t),e_t} + 0.1427\eta^{m(f:e_t),e_t}$. The spectrum of consequences for the CPI elasticity are visualized in figure 1, with the vertical dimension capturing η^{P_t,e_t}.

Observe that in the base case reported in table 6, the CPI elasticity of 0.0838 is reduced to the extent that flexibility occurs on either margin (both $\eta^{\mu(h:e_t),e_t}$ and $\eta^{m(f:e_t),e_t}$ are negative). However, the changes in these two parameters have significantly different quantitative impacts. The impact on CPI sensitivity of increasing the elasticity in distribution expenditures is more than twice as large as the impact of an equal size increase in the imported input share adjustment.

Theoretical and empirical analyses of the determinants and quantitative impact of each of the adjustment margins are an open research issue. Intuitively, one might expect the elasticity of distribution expenditures to be larger when fluctuations in import prices and exchange rates are viewed as transitory. However, in such a scenario, it is also likely that production flexibility is closest to zero. Therefore, the

FIGURE 1.—CPI PASS-THROUGH AND FLEXIBILITY DIMENSIONS

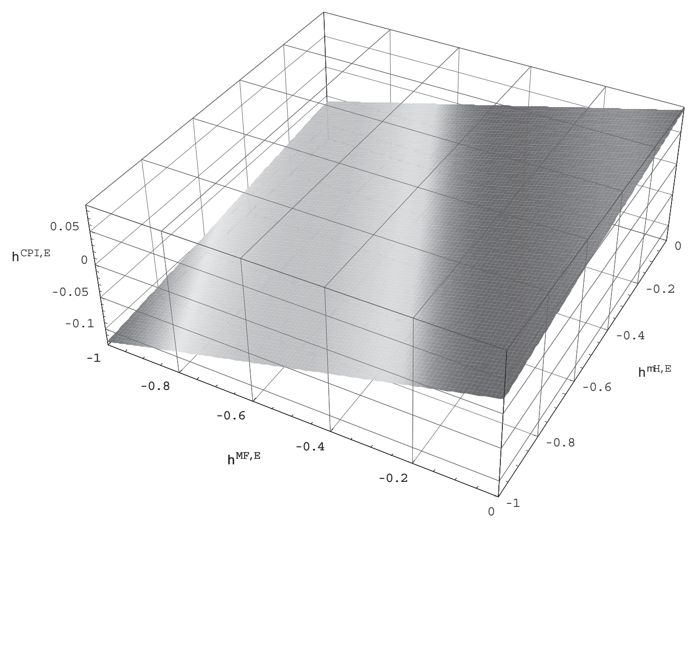

TABLE 7.—EXCHANGE RATE PASS-THROUGH INTO THE CPI

			Exchange Rate Pass-Through into CPI			
			Calibrated, $\theta = 4$			
	Estimated-Pass Through into Border Prices (1)	Estimated Pass-Through into CPI (2)	Assuming $\eta^{m(f:e_t),e_t} = 0$ (3)	Assuming $\eta^{m(f:e_t),e_t} = -.5$ (4)	Assuming Estimated Import Price Pass-Through and Assuming $\eta^{m(f:e_t),e_t} =$ 0 (5)	−0.5 (6)
Australia	0.67*+	0.09*	0.20	0.17	0.13	0.12
Austria	0.10	−0.09	0.33	0.27	0.03	0.03
Belgium	0.68	0.08+	0.36	0.32	0.25	0.22
Denmark	0.82*	0.16*+	0.23	0.18	0.19	0.15
Estonia			0.53	0.46		
Finland	0.77	−0.02+	0.22	0.18	0.17	0.14
France	0.98*	0.48*+	0.21	0.19	0.21	0.19
Germany	0.80*	0.07+	0.25	0.22	0.20	0.17
Greece			0.36	0.31		
Hungary	0.78*	0.42*+	0.46	0.42	0.36	0.33
Ireland	0.06	0.08+	0.61	0.56	0.04	0.03
Italy	0.35+	0.03+	0.24	0.21	0.08	0.07
Netherlands	0.84*	0.38*+	0.29	0.24	0.24	0.20
New Zealand	0.22+	−0.10*+	0.23	0.19	0.05	0.04
Norway	0.63*	0.08+	0.29	0.25	0.18	0.16
Poland	0.78*	0.59*+	0.25	0.23	0.20	0.18
Portugal	1.08*	0.60*+	0.36	0.32	0.39	0.35
Spain	0.70*	0.36*+	0.21	0.19	0.15	0.13
Sweden	0.38*+	−0.11+	0.32	0.29	0.12	0.11
United Kingdom	0.46*+	−0.11+	0.24	0.20	0.11	0.09
United States	0.42*+	0.01+	0.08	0.07	0.04	0.03
Average	0.21	0.15	0.30	0.26	0.15	0.13

Note: *(+) indicates exchange rate pass-through significantly different from 0 (1) at a 5% confidence level. Most data are quarterly, spanning 1975 through early 2003.
Source: 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.

net impact on CPI effects of import price movements may not be clear until informed by ongoing research.

So far, this section has shown that the pass-through elasticity of exchange rates into CPIs highly depends on the role that tradables goods have in the economy—both tradables in consumption and tradables used as 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 for both the prices of directly consumed nontradable goods and tradable goods in the final consumption baskets of most developed economies.

Comparison with estimated CPI elasticities. Table 7, column 1, shows the well-established result that exchange rate pass-through into import prices is typically not complete and differs substantially across countries. Column 2 shows the noisy estimated CPI sensitivity to exchange rates for the same group of countries. Average pass-through into consumer prices is 0.17 over the long run, with larger standard deviations.[12] Columns 5 and 6 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 3 and 4, on average by about 50%.

The calibrated sensitivities of the CPI with respect to exchange rates are higher than most of the estimated values. We have argued that estimated CPI elasticities are difficult to interpret, thus justifying the calibration benchmarks. A combined number of alternative possible explanations likely explains the gaps. First, assumed parameter values of θ may

[12] Follows the standard pass-through estimation in Campa and Goldberg (2005). There has been debate over the stability over time of these pass-through rates, as summarized in Goldberg and Dillon (2007) and IMF (2007), but the basic pattern is maintained. The regressions over full sample data for Belgium and France, starting in 1975, support long-run pass-through elasticities in excess of 1. 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.

be too high in our base case scenario. Second, the base case scenarios may not be assuming the appropriate degree of production and distribution expenditure flexibility across countries. Finally, as discussed in Section I, the estimated CPI sensitivities also may reflect monetary reaction functions, so that contractionary monetary policies may offset overall CPI reactions that otherwise would have been visible from exchange rate and import price fluctuations. In this context, if monetary policy fully stabilized CPI fluctuations, then empirical pass-through would be zero, and the model used in this paper takes monetary policy as exogenous to exchange rate fluctuations.

V. Conclusion

This paper has explored the scale of the main channels for shocks to border prices of imports, for example, due to exchange rate changes, to effect consumer prices across 21 countries. Distribution expenditure shares, which average 32% to 50% of the total cost of goods, significantly damp the transmission of import prices into final consumption prices of imported products. Consumption prices of domestically produced goods, traded goods, and nontraded goods are also affected, increasing as imported input use has risen over time. While calibrations usually treat nontraded goods production as using only domestic inputs, we show that the share of 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%. Tradable goods production use of imported components ranges from 10% of total costs in the United States[13] to up to 49% for Ireland. Integrated production has become large enough to dominate the direct consumption of imported goods as the channel for transmission of changes of import prices or exchange rates into the CPI.

We also have demonstrated that flexibility in production supplies sourcing and in the size of distribution margins reduces the overall extent of pass-through into consumer prices. More flexible economies retain more insulation of prices from global shocks, containing direct inflationary affects but perhaps passing the consequences through to the real economy to a greater extent. This latter type of transmission of shocks internationally remains a vibrant area for research. In the event of a rise in import prices, monetary policy aimed at countering the impact on the inflation rate would offset part of the muted rise in the consumption prices of imported goods but also respond to a rise in production costs experienced throughout the economy.

[13] This value is based on data from 1997. This share is likely to be substantially lower than imported input shares a decade later since the late 1990s were characterized by an acceleration of internationally integrated production.

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DATA APPENDIX

Input-Output Databases

We use the input-output tables to compute the measure of imported inputs into production. Our measure of imported inputs therefore refers the value of the sum of imports in the use table relative to total (sum of domestic and imports) intermediate inputs for each industry. 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) and then map these to 58 industry headings (of which 29 are manufacturing and primary industries) that we treat as comparable across countries. This harmonization and the industry definitions are not exact across countries, but we nonetheless treat these as matched in our specific empirical discussions. Distribution margins on nontradable industries in the input-output tables are zero. 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. Extensive details on specific industries and data sources are provided in Campa and Goldberg (2006). Table A1 provides details by industry on patterns of imported input use and distribution share margins.

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 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, agriculture, 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, agriculture, 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.

TABLE A1.—INDUSTRY PATTERNS OF IMPORTED INPUT USE AND DISTRIBUTION MARGIN SHARES

Product		Imported Inputs			Distribution 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; with services	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, with services	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 nonmetallic 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, excl machin. and equip.	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

Note: Product names given with CPA (Classification of Products by Activity) codes. 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 nonnegative 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. = not elsewhere classified.