EXCHANGE RATE PASS-THROUGH INTO IMPORT PRICES

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Abstract—We provide cross-country and time series evidence on the extent of exchange rate pass-through into the import prices of 23 OECD countries. We find compelling evidence of partial pass-through in the short run, especially within manufacturing industries. Over the long run, producer-currency pricing is more prevalent for many types of imported goods. Countries with higher rates of exchange rate volatility have higher pass-through elasticities, although macroeconomic variables have played a minor role in the evolution of pass-through elasticities over time. Far more important for pass-through changes in these countries have been the dramatic shifts in the composition of country import bundles.

I. Introduction

Though exchange rate pass-through has long been of interest, the focus of this interest has evolved considerably over time. After a long period of debate over the law of one price and convergence across countries, beginning in the late 1980s exchange rate pass-through studies emphasized industrial organization and the role of segmentation and price discrimination across geographically distinct product markets. More recently pass-through issues have played a central role in heated debates over appropriate monetary policies and exchange rate regime optimality in general equilibrium models.[1] These debates have broad implications for the conduct of monetary policy, for macroeconomic stability, for international transmission of shocks, and for efforts to contain large imbalances in trade and international capital flows.

These debates hinge on the issue of the prevalence of producer-currency pricing (PCP) versus local-currency pricing (LCP) of imports, and on whether exchange rate pass-through rates are endogenous to a country's monetary performance. Low import price pass-through means that nominal exchange rate fluctuations may lead to lower expenditure-switching effects of domestic monetary policy. As a consequence of this insulation, monetary policy effectiveness is greater for stimulating the domestic economy. Taylor (2000) also has noted the potential complementarity between monetary stability and monetary effectiveness as a policy instrument. The idea is that if pass-through rates are endogenous to a country's relative monetary stability, periods of more stable inflation and monetary performance also will be periods when monetary policy may be more effective as a stabilization instrument. Concerns can be raised, then, about whether measured degrees of monetary policy effectiveness are fragile and regime-specific if the degree of exchange rate pass-through is highly endogenous to macroeconomic variables.[2] The degree of aggregate exchange rate pass-through, and its determinants, are therefore important for the effectiveness of macroeconomic policy.

Although pass-through of exchange rate movements into a country's import prices is central to these macroeconomic stabilization arguments, to date only limited relevant evidence on this relationship has been available.[3] The first goal of our paper is to provide extensive cross-country and time series evidence on exchange rate pass-through into the import prices of 23 OECD countries. Using quarterly data from 1975 through 2003, we estimate pass-through elasticities after appropriately controlling for shifts in exporter marginal costs and demand conditions. Our cross-country evidence is strongly supportive of partial exchange rate pass-through in the short run (defined as one quarter) at the level of the aggregate import bundle.

The unweighted average of pass-through elasticities across the OECD countries is approximately 46% over one quarter, and approximately 64% over the longer term. The United States has among the lowest pass-through rates in the OECD, at approximately 25% in the short run and 40% over the longer run. Corresponding rates of pass-through into German import prices are approximately 60% and 80%.

What explains differences across countries in exchange rate pass-through into import prices? A promising recent direction of research supplements the earlier microeconomic arguments by focusing on macroeconomic variables. Most notably, theoretical works argue that volatility in monetary aggregates and exchange rates of countries should influence the choice of invoice currencies in trade [for example, see Devereux and Engel (2001)]. In equilibrium, countries with low relative exchange rate variability or stable monetary policies would have their currencies chosen for transaction invoicing. The low-exchange-rate-variability countries would also be those with lower exchange rate pass-through.

Received for publication March 24, 2003. Revision accepted for publication December 29, 2004.

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The views expressed in this paper are those of the individual authors and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System. We thank anonymous referees, Rudiger Dornbusch, Richard Marston, Andrew Rose, and Alwyn Young for helpful comments, as well as seminar participants at various universities, the ASSA, NBER, BIS, and Federal Reserve Bank of New York. We also thank Leticia Alvarez and Glenda Oskar for their research assistance.

[1] The implications of pass-through performance for optimal monetary policy also are explored in Corsetti and Pesenti (2005), Obstfeld (2001), Devereux (2001), and Devereux and Engel (2003), among others.

[2] See Taylor (2000). The role of the invoicing decisions of producers in influencing pass-through rates is explored in recent work by Devereux and Engel (2001) and Bacchetta and Van Wincoop (2001).

[3] As surveyed by Goldberg and Knetter (1997), most of the available evidence is from very narrowly defined export industries, with an emphasis often placed on the pricing-to-market behavior of exporters. Knetter (1993), Marston (1990), Goldberg and Knetter (1997), and Kasa (1992) use export prices or export unit values from specific countries to multiple destinations with the intent of identifying price discrimination or pricing-to-market activity. Whereas import prices are by definition just the local-currency value of another producer's export prices, the import price series aggregate across producers from all source countries and across a broader array of prices. For the purpose of the relevant macroeconomic debate, import price series with aggregation are the appropriate units for analysis.

The Review of Economics and Statistics, November 2005, 87(4): 679–690

We find evidence that countries with less exchange rate and inflation variability are likely to have lower rates of pass-through of exchange rates into import prices. This is a weak systematic positive relationship between volatility over recent decades and pass-through. There are no similar systematic relationships between country size and pass-through into aggregate import bundles.

Another issue receiving attention in the recent macroeconomic debate is the stability of exchange rate pass-through rates over time. Taylor (2000) and Goldfajn and Werlang (2000), among others, have argued that pass-through rates may have been declining over time. The Brazilian experience of the late 1990s is often cited. In this experience, consumer prices responded very little to a large home-currency depreciation, in sharp contrast with past depreciation episodes. The issue posed in these and related studies is whether this decline in pass-through, and a purported more general decline in pass-through rates, are related to improved macroeconomic conditions in the importing countries.[4] We further ask whether these issues extend to the OECD countries. Our work emphasizes the importance of separating the analysis of aggregate pass-through rates into two parts. The first is a border phenomenon: to what extent are there changes in pass-through rates at the level of import prices, that is, at the border? Second, to what extent are these border price changes transmitted to consumers or even offset by anticipated current or future monetary policy changes? Our analysis specifically deals with the former question.[5]

Out of the 23 OECD countries for which appropriate statistical tests could be performed, we confirm that there has been a weak tendency toward declines in exchange rate pass-through rates. However, the strength of this result should not be overstated. Low power in the statistical tests performed and the limited ability to detect changes in pass-through over time requires that these results are evaluated with caution. Pass-through declines were statistically significant in only four countries, but significant increases in pass-through into import prices also were evident in two countries. The United States is not one of the countries that have experienced statistically significant declines in the pass-through of exchange rates into their import prices.

We continue by undertaking a direct examination of the underlying drivers that may be causing the change in pass-though rates into aggregate import prices. For any country, such shifts could arise either because of changes in the underlying composition of products in a country's import bundle, or because of changes in the pass-through elasticities associated with these product groups. At the level of specific disaggregated products, pass-through elasticities could evolve because of changes in industry competitive conditions or changes in macroeconomic conditions.

We are able to study the role of import composition at a broad level because the OECD makes available import price series, by country, at the level of five import categories: food, manufacturing, energy, raw materials, and nonmanufactured products. We use these import series to document the prevalence of LCP, PCP, or partial pass-through, and to undertake tests for stability in pass-through in these disaggregated categories. Once again, there is strong cross-country evidence on the prevalence of partial pass-through into import prices. Both PCP and LCP are strongly rejected as short-run descriptions of pass-through into manufacturing and food import prices. Because manufacturing trade now dominates the imports of OECD countries, the partial pass-through of overall import prices is explained. But the issue of stability of pass-through remains relevant for the broader debate.

Interestingly, these pass-through rates for disaggregated import prices are highly stable over the two decades of data examined. We use these stable pass-through elasticities along with time-varying data on import composition to construct a series that captures the effect of import composition on aggregate pass-through. We then run a horse race, contrasting the contribution to aggregate pass-through changes of time-varying macroeconomic series (country size, inflation, and exchange rate variability) against that of trade composition. Despite the fact that macroeconomic variables—especially exchange rate variability—matter for the ranking of country pass-through levels [consistent with Bacchetta and Van Wincoop's (2005) and Devereux and Engel's (2001) conjectures], these variables have not been quantitatively important for explaining declining exchange rate pass-through into import prices across the OECD countries. Far more important for overall pass-through rates are changes in the composition of industries in each country's import basket. In particular, the move away from energy as a high proportion of the import bundles and the related substantial rise in the share of manufactured products has been the primary driver behind recent pass-through changes into import prices among numerous OECD countries.

II. Exchange Rates and Prices

The microfoundations of pricing behavior by exporters are a useful starting point for understanding the dynamics of exchange rate pass through into import prices. The import prices for any country j, $P_t^{m,j}$, are a transformation of the export prices of that country's trading partners, $P_t^{x,j}$, using the exchange rate (domestic currency per unit foreign currency) E_t^j:

$$P_t^{m,j} = E_t^j P_t^{x,j}. \quad (1)$$

[4] An alternative explanation rests on monetary reaction functions, as in Gagnon and Ihrig (2004).

[5] Our focus should not be confused with that of related recent papers that attempt to explain the pass-through of exchange rates into a country's CPI. In these papers, exchange rate movements lead to import price pass-through. These enter with weights into the aggregate CPI of countries, with the weights possibly to be adjusted to reflect distribution costs as in Burstein, Neves, and Rebelo (2001) or central bank reaction functions as in Gagnon and Ihrig (2001).

The export prices, in turn, are a markup ($mkup_t^x$) over exporter marginal costs (mc_t^x). Using lowercase letters to reflect logarithms, we rewrite equation (1) as

$$p_t^m = e_t + mkup_t^x + mc_t^x, \tag{2}$$

where for simplicity we have dropped the country superscript *j*.

We further allow markups to have both an industry-specific fixed effect and a component that is sensitive to macroeconomic conditions, expressed for simplicity at this point as a function only of the exchange rates,

$$mkup_t^x = \phi + \Phi e_t, \tag{3}$$

and specify exporter marginal costs as rising with export market wages, w_t^x, and destination market demand conditions y_t:[6,7]

$$mc_t^x = c_0 y_t + c_1 w_t^x, \tag{4}$$

so that import prices are written in general form as

$$p_t^m = \phi + (1 + \Phi)e_t + c_0 y_t + c_1 w_t^x. \tag{5}$$

This structure permits the exchange rate pass-through $\beta = 1 + \Phi$ to depend on the structure of competition in the industry. This is consistent with the large literature on explaining cross-sectional differences on exchange rate pass-through, which has been summarized simply and eloquently by Dornbusch (1987) and Marston (1990), among others, and supported empirically by Knetter (1993) and Yang (1997). This structure also has a direct analogy in the discussion of producer- versus local-currency pricing. If $\Phi = 0$, producer-currency pricing takes place; if $\Phi = -1$, local-currency pricing does, and exporters fully absorb the fluctuations in exchange rates in their own markups.

III. Exchange Rate Pass-through into Aggregate Import Prices: The Evidence

A. Data and Estimation Methods

We capture the arguments of equation (5) through a log linear regression specification similar to that tested throughout the exchange rate pass-through literature:[8]

$$p_t = \alpha + \delta w_t + \beta e_t + \varphi y_t + \varepsilon_t, \tag{6}$$

where p_t are local currency import prices, e_t is the exchange rate, w_t is a primary "control" variable representing exporter costs, and y_t is a vector of other controls, including the real GDP of the destination market. Biased estimates of the pass-through coefficient could arise if foreign wages or GDP are correlated with exchange rates but omitted from the regression.

We have used quarterly data on import price indices from the OECD, compiled quarterly for 23 OECD countries, with the series commencing around 1975 and ending in 2003.[9] Nominal exchange rates are from the International Financial Statistics (series *neu*), defined in our specifications as domestic currency per unit of foreign currencies (1/*neu*), so that home-currency depreciations appear as increases in the nominal exchange rate series. Real exchange rates also are from the International Financial Statistics (series *reu*). The real GDP series used are those of the importing countries (source: International Financial Statistics).

It is more difficult to find a primary control variable that captures the shifting relative costs of a country's aggregated trading partners. 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 $W_t^j = neu_t^j \cdot P_t^j / reu_t^j$ by 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.

For each of the 23 aggregate import price indices, the first stage of our analysis entails estimating short-run (one quarter) and long-run pass-through elasticities $\hat{\beta}$ from equation (5). 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 to exchange rates,[10] the estimation equation is

$$\Delta p_t^j = \alpha + \sum_{i=0}^{4} a_i^j \Delta e_{t-i}^j + \sum_{i=0}^{4} b_i^j \Delta w_{t-i}^j + c^j \Delta g dp_t^j + \vartheta_t^j. \tag{7}$$

[6] More precisely, one should include as the appropriate demand variable an index of income levels across the producer's home market and the destination market for its exports. Because we do no have information on the composition of demand facing exporters in different countries, our proxy here is the GDP of the importing country.

[7] The exchange rate can also be an argument in the exporter's cost function to the extent that the exporter relies on imported inputs or has other costs that move with the relative value of the destination market currency. See Campa and Goldberg (1997), Feenstra (1998), and Hummels, Ishii, and Yi (2001) for evidence on increasing reliance on imported inputs and vertical integration of production across countries.

[8] Goldberg and Knetter (1997) review the relationships between these studies. Beyond the industrial organization themes, there also are studies that allow for pass-through elasticities to differ between appreciation and depreciation periods (Swamy & Thurman, 1994) or to be distinct for anticipated versus unanticipated exchange rate changes (Marston, 1990).

[9] We limit our sample to the OECD countries because we also need corresponding information on the import prices of more disaggregated categories of import. These disaggregated series are not consistently available outside of this OECD database. A detailed description of the data is provided in the data appendix.

[10] We include up to four lags of exchange rates and foreign prices and 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. An alternative specification, which used a lagged dependent variable and relied on a partial adjustment model, generated very similar empirical results (not reported in this version of the paper). However, the lagged-dependent-variable model imposed a set of constraints on model coefficients that were rejected in the majority of cases. Consequently, we report the results of only the gradual adjustment specification depicted in equation (7).

The short-run relationship between exchange rates and the import prices of country j is given by the estimated coefficient a_0^j. The long-run elasticity is given by the sum of the coefficients on the contemporaneous exchange rate and four lags of exchange rate terms $\sum_{i=0}^{-4} a_i^j$. The estimation methodology applied is ordinary least squares on variables in log differences, selected after we performed extensive checks on the stationarity of series and on (lack of) appropriateness of a cointegration approach.[11]

B. *Estimates of Exchange Rate Pass-through into Aggregate Import Prices*

Estimates of exchange rate pass-through into import prices for the OECD countries are presented in table 1. Taking unweighted averages across countries, we find that average pass-through into import prices is 0.46 in the short run and 0.64 in the long run. These averages mask interesting cross-country differences in pass-through into import prices. The United States has relatively low pass-through, 23% within one quarter and 42% over the longer run. Pass-through estimates for countries such as France, Germany, and Switzerland are closer to 60% in the short run and 80% to 90% over the longer run. Smaller European countries typically have noisier and less stable pass-through rates, but a precise relationship between pass-through and country size is not empirically significant.

A recurrent issue in the recent macroeconomics literature is the prevalence of LCP stability versus PCP. In our specifications, LCP represents a null hypothesis of zero pass-through whereas PCP implies a pass-through of unity. Notation included in table 1 highlights our tests for the existence of LCP, PCP, or partial pass-through into import prices. LCP can be rejected for 20 of the 23 countries in the short run and 18 of 23 in the long run. PCP can also be overwhelmingly rejected in the short run (for 22 out of the 23 countries), but in the long run is much harder to reject (only for 7 of the 23 countries). For countries in the OECD, we overwhelmingly reject complete pass-through (or PCP) and zero pass-through (or LCP) as a description of aggregate import prices in the short run. In the longer run, pass-through elasticities are larger and closer to 1; thus PCP is better supported as a longer-run characterization.[12]

TABLE 1.—ELASTICITIES OF EXCHANGE RATE PASS-THROUGH INTO AGGREGATE IMPORT PRICES

Country	Elasticity	
	Short Run	Long Run
Australia	.56*†	.67*†
Austria	.21†	.10
Belgium	.21†	.68
Canada	.75*†	.65*†
Czech Republic	.39*†	.60*
Denmark	.43*†	.82*
Finland	.55*	.77*
France	.53*†	.98*
Germany	.55*†	.80*
Hungary	.51*†	.77*
Ireland	.16†	.06
Italy	.35*†	.35†
Japan	.43*†	1.13*
Netherlands	.79*†	.84*
New Zealand	.22*†	.22†
Norway	.40*†	.63*
Poland	.56*†	.78*
Portugal	.63*†	1.08*
Spain	.68*†	.70*
Sweden	.48*†	.38*†
Switzerland	.68*†	.93*
United Kingdom	.36*†	.46*†
United States	.23*†	.42*†
Average	.46	.64

Note: * (†) implies that an elasticity is significantly different from 0 (1) at the 5% level.

C. *Are There Differences across Countries in Aggregate Pass-through?*

We have tested for the statistical differences across countries in pass-through elasticities shown in table 1 by reestimating equation (7) with the data pooled for all countries and imposing the restriction that estimated coefficients must be the same across countries. We rejected this hypothesis at the 1% level. We also reestimated equation (7) for the pooled sample, allowing coefficients in the non-exchange-rate terms to vary by country, and we rejected the hypothesis of equality of exchange rate pass-through across countries.

[11] We were unable to reject the hypothesis that the (log) series of import prices, foreign costs, and effective exchange rates were nonstationary. Dickey-Fuller unit root tests on the logarithmic values of the import price, foreign costs, and exchange rate series in an econometric specification with time trends reject the unit root hypothesis at the 5% level in only 2 of 69 instances (three series for 23 countries). We therefore accept that the (log) series of import prices, foreign costs, and effective exchange rates are nonstationary, with the strong caveat that these stationarity tests have low power.

We performed additional tests to determine whether these three variables were cointegrated, that is, whether a linear combination of these variables resulted in a stationary process. Abstracting from the issue of low power of these tests, and despite predictions of theory, we rejected the cointegration hypothesis and consequently do not apply an error correction model. We reached this conclusion by first rejecting that the log real exchange rate is stationary and rejecting the vector $(1,1,-1)$ as a cointegrating vector as suggested by the theory of the real exchange rate. We also tested for the possibility that a cointegrating vector existed but was different from what exchange rate theory predicts. Specifically, we ran a model where $p_t = a + be_t + cw_t + u_t$, and estimated $\hat{u}_t = \rho\hat{u}_{t-1} + \varepsilon_t$. We tested whether the estimated coefficient ρ is different from unity, and rejected for only three cases the hypothesis that ρ is different from unity at the 5% level. This is slightly higher than the 1.23 instances that statistical error would suggest, but still very low.

[12] The results of these tests will be sensitive to whether the pass-through regression coefficients are unconstrained, as in the specification reported, or constrained to lie between 0 and 1. Although theoretically it is possible to justify pass-through rates greater than 1, such rates are unlikely to be observed. If our estimated coefficients are restricted to the finite interval [0,1], we can correct the standard errors of the estimated coefficients using the Fisher transformation. Using this transformation, we tested for the significance of the transformed number $z = 0.5[\ln(1 + \hat{\beta}) - \ln(1 - \hat{\beta})]$. This transformation tends to reject equality to 0 and 1 slightly more frequently. For instance, in table 1, 18 out of 23 countries rejected a coefficient equal to 1 in the short run. In the long run this happened for 17 out of the 23. We have performed similar tests for the disaggregate import price data, with similar results.

TABLE 2.—DETERMINANTS OF PASS-THROUGH ELASTICITIES INTO IMPORT PRICES: ALTERNATIVE CROSS-COUNTRY PANEL REGRESSION SPECIFICATIONS

Exogenous Variable [Mean]					
			A. Determinants of Short-Run Elasticities		
Money growth	2.566**				0.274
[0.010]	(0.284)				(0.340)
Inflation		14.887**			7.394**
[0.004]		(1.054)			(1.422)
Exchange rate volatility			3.900**		2.370**
[0.111]			(0.251)		(0.465)
Real GDP				0.275	0.002
[2.261]				(0.340)	(0.007)
			B. Determinants of Long-Run Elasticities		
Money growth	5.129**				0.954
[0.010]	(0.693)				(0.719)
Inflation		20.360**			10.002**
[0.004]		(1.567)			(1.836)
Exchange rate volatility			7.010**		2.100**
[0.111]			(0.482)		(0.727)
Real GDP				1.029	0.069**
[2.261]				(0.718)	(0.013)
Adj. R^2	0.17	0.22	0.23	0.17	0.32

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. All regressions are weighted least squares.

Various theoretical arguments have been made for cross-country differences in exchange rate pass-through rates. Among these is a role for the relative stability of local monetary policy, as in Devereux and Engel (2001). If exporters set their prices in the currency of the country that has the most stable monetary policies, import prices in local currency terms should be more stable in countries with more stable monetary policy. All else equal, exchange rate pass-through should be higher for countries with more volatile monetary policy. Exchange rate variability and local monetary volatility could also enter through exporter competition for market share, as discussed in Froot and Klemperer (1989): exchange rate pass-through may be lower when nominal exchange rate variability is high and exporters to a country try to maintain local market share. Country size may be another important factor in ranking pass-through elasticities of countries. As initially proposed by Dornbusch (1987), exchange rate pass-through may be higher if the exporters are large in number relative to the presence of local competitors. One approximation to this notion is that pass-through elasticities might be inversely related to country real GDP. An alternative approach would be to also consider measures of sector-specific openness for countries.

We test for the importance of these alternative hypotheses by reestimating the model in equation (7) and allowing the coefficients on short-run and long-run exchange rate pass-through to be a function of observable macroeconomic variables, so that the estimated coefficients for pass-through are replaced in equation (7) by the following expression:

$$a_i^j = \beta_i x_t^j \qquad \text{for} \quad i = 0, \ldots, 4, \tag{8}$$

where x^j is a vector representing all the exogenous regressors that may explain cross-country differences in exchange rate pass-through. We have used as exogenous variables: country-specific quarterly inflation rates, money growth rates, exchange rate volatility, and real GDP during the sample period. The time series variables used in constructing the right-side macrovariables are all measured quarterly over the sample period 1975:1 to 2003:4. These variables are as follows: *Money* is measured as the annualized growth rate of the money supply (in logs); *Inflation* is the annualized inflation rate, based on consumer price indices (in logs); *Exvol* is the average of the monthly squared changes in the nominal exchange rate during the previous year; *GDP* is the nominal value in national currency deflated using the CPI deflator and converted into U.S. dollars at the average 1996 nominal exchange rate.

The results of this specification exploring the macroeconomic determinants of exchange rate pass-through are presented in table 2. Each column in the table reports the estimated coefficients (and *t*-statistics in parentheses below) of the variables included in each specification. These results show that country-specific rates of exchange rate pass-through into import prices are significantly correlated with inflation, money growth, and nominal exchange rate volatility. Inflation and money growth are highly correlated variables, and when they are included jointly as determinants of exchange rate pass-through, we find that inflation rates are statistically significant, but the rate of money growth is not (last column of table 2). This result is intuitive. Countries with higher rates of inflation should have higher rates of pass-through of exchange rates into import prices. Countries with more nominal volatility have higher pass-through rates. The result that lower nominal volatility is associated with lower pass-through is consistent with the main theoretical

TABLE 3.—EXCHANGE RATE PASS-THROUGH TENDENCIES IN DISAGGREGATED BUNDLES OF IMPORT PRICES

	Food	Energy	Raw Materials	Manufacturing	Nonmanufactured
Short run:					
Reject LCP ($a_0^j = 0$)	17	8	15	20	12
Reject PCP ($a_0^j = 1$)	16	4	8	23	8
Reject both LCP and PCP	11	1	6	19	4
Average pass-through elasticity	0.46	0.75	0.62	0.43	0.62
Long run:					
Reject LCP ($\sum_{i=0}^{4} a_i^j = 0$)	14	4	13	18	6
Reject PCP ($\sum_{i=0}^{4} a_i^j = 1$)	9	2	5	16	5
Reject both LCP and PCP	6	0	3	12	1
Average pass-through elasticity	0.66	0.81	0.85	0.62	0.78

Entries in table show number of countries for which each hypothesis is rejected. Total number of countries is 23 for all imports, 22 for disaggregated products.
Note: LCP represents Local Currency Pricing. PCP represents Producer Currency Pricing.

results of Devereux and Engel (2001). The role of country size, however, is insignificant in the rankings of pass-through rates across countries. Despite the observation that U.S. pass-through rates are quite low, across the OECD there is no systematic relationship between pass-through and country real GDP. The point estimate is insignificant, reflecting the fact that some large countries have high pass-through (Japan) whereas some small countries have low pass-through (Czech Republic).

D. Stability of Aggregate Pass-through Elasticities

As noted in our introduction, an outstanding issue is whether pass-through rates have been declining over time, and if so, whether such declines are related to changes in macroeconomic policy variables. We can confront the first part of this issue directly by performing structural-change tests on the pass-through elasticities, although such tests will have limited statistical power in the small data sample available for analysis. One standard test is a Chow test, wherein we first assume an exogenously imposed breakpoint in the pass-through relationship and perform associated tests for parameter stability. A second set of tests we perform has a similar flavor, but instead allows for endogenously determined structural breakpoints.[13] In the process of doing these tests, we further identify the dominant directions of pass-through changes. The tests are implemented for all countries except Hungary and the Czech Republic, for which the available data samples are shorter than for the other countries.

In our implementation of the Chow tests we compare elasticities estimated over the first half of the sample, 1975 through 1989, with those over 1990 through 2003. The results from this split-sample approach are that there is a mix of increases and decreases in exchange rate pass-through elasticities across countries. Short-run and long-run exchange rate pass-through elasticities declined for 15 of the 21 countries, and increased for the other 6 countries. Though declines appear more prevalent, the Chow tests detect significant changes in only four of these cases.

The second set of stability analyses test for the presence of a structural break in pass-through using the methods proposed by Andrews (1993) and Andrews and Ploberger (1994). These methods test for the existence of a structural breakpoint in the stated relationship at some unknown date within the sample period. These tests have the advantage that the researcher does not need to specify a priori the date at which the structural break takes place. However, these tests are asymptotic, and their power in our context is quite limited by the number of observations in our import price series (generally around 100 quarters per series). Though short-run pass-through stability is also rejected for seven countries, it is difficult to assign the timing of instability to a particular break date, suggesting that the instability is gradual rather than associated with a distinct point in time. We can never reject stability of long-run pass-through according to these tests.

E. Exchange Rate Pass-through into Disaggregated Import Prices

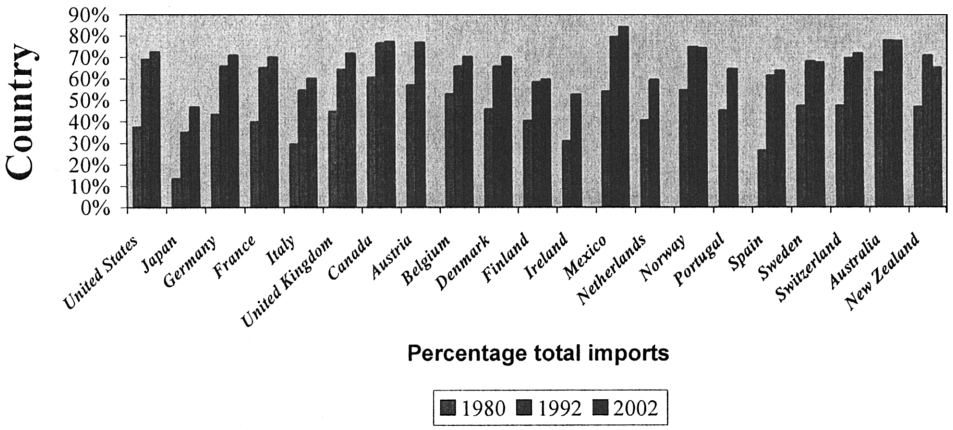
In addition to the country aggregates on import prices, the OECD compiles data on disaggregated import prices at the country level for the same countries in the sample (except Iceland) for five product categories: food, energy, raw materials, manufacturing, and nonmanufactured products. We reestimated equation (7) for this sample of disaggregated price data.[14] As detailed in appendix table A1[15] and sum-

[13] Hansen (2001) provides a good critique of different types of structural-change tests.

[14] We also performed tests for nonstationarity of each of these price series and, by country, for the existence of a cointegrating relationship between these series, the exchange rate, and the foreign price. The results of these tests were similar to those for the aggregate import price series. Mainly, we could not reject nonstationarity of import price levels, and we could reject the existence of a cointegrating relationship among the three variables.

One shortcoming of our estimation strategy is that the same weighted foreign-wage variable is used in regressions for the different import aggregates. This assumption results in measurement error that may bias the foreign-wage variable to the extent that country imports of different goods are sourced from countries of different importance as trade partners.

FIGURE 1.—MANUFACTURED GOODS SHARE OF IMPORTS



marized in table 3, most industries exhibit a striking degree of partial pass-through. For each product category except energy, we reject the hypothesis of zero exchange rate pass-through (LCP) for more than half of the countries. For manufacturing and food, we similarly reject complete pass-through (PCP). The evidence in support of partial pass-through is strongest for manufacturing imports, for which short-run pass-through differs significantly from both 0 and 1 in 19 out of 22 countries. Food also exhibits partial pass-through in the short run. Local-currency pricing is often rejected for nonmanufactured products and raw materials, and rejections of producer-currency pricing are more mixed across countries. We have explored further the possibility of misspecified equations for pass-through of exchange rates into energy prices by using only bilateral exchange rates against the U.S. dollar and an alternative exporter cost series (the U.S. dollar price of energy). In these specifications, whereas short-run pass-through is less than 1 for most countries, long-run pass-through is essentially 1 in all cases (only rejected in one case).[16]

We conduct further analysis of the pass-through elasticities using time-series panel specifications within country, and test whether the pass-through elasticities of any industries differ statistically from a base industry. Taking prices of manufacturing imports as a base, we find somewhat regular patterns in the rejections of equality of pass-through coefficients across industries. The pass-through of exchange rate changes into food and agricultural products is not statistically different from that into manufacturing in any of the 22 country regressions. The most extreme contrasts are between the pass-through into manufactured-goods prices and that into the prices of energy products: in 9 (8) of 22 countries we see statistically different coefficients on energy price sensitivity to exchange rates in the short run (long run).[17]

These findings of different pass-through elasticities across industries, in particular via the role of energy imports, suggest a possible motivation for changing pass-through into aggregate bundles of import prices over time. The countries of our sample have had large changes in the composition of their import bundles since the 1970s, and continuing through into the early 2000s. The main forces at work have been tremendous increases in the relative importance of manufacturing imports and declines in the relative importance of raw materials, and especially energy.

Figure 1 shows the evolution in import composition for the countries in our study, specifically depicting the share of manufactured goods in country import bundles for the years 1980, 1992, and 2002. The first bar shown for each country depicts the manufacturing share for 1980. In 1980 manufacturing imports typically were less that 50% of the overall (merchandise) import bill for most countries. Countries heavily reliant on imported energy had much smaller shares of manufacturing imports in total imports: notably, for Japan, Italy, and Spain these shares were below 30%. Due to lower energy prices, changes in energy policies, and the dramatic growth of manufacturing trade, by the 1990s there was a striking cross-country shift in the composition of imports. By 1992 manufactured products accounted for

We suspect the errors associated with this assumption to be strongest for the energy and raw-material imports of countries, where supply is likely to be concentrated in a set of countries unrepresentative of the mix in the country's aggregate import bundle. However, there is a significant data constraint in building import marginal cost indices that are industry- and country-specific. We instead use a methodologically homogeneous approach for each country, applying an index measure of foreign unit costs, by country, in the regressions.

[15] Appendix table A1 provides these estimates, by country. Another important issue with respect to monetary policy is the pass-through comparison for final-goods prices versus imported-intermediate-goods prices (Obstfeld, 2001). Energy and raw materials can be viewed as being closer to classification as imported intermediate goods than food, manufacturing, and nonmanufacturing products.

[16] These regressions exclude the United States. We also performed pass-through estimation for more disaggregated product categories within the energy sector. As reported in the working paper version of this paper (Campa & Goldberg, 2002), pass-through into the import prices of three more disaggregated energy imports—coking coal, steam coal, and oil—were more precisely estimated. Coking coal and steam coal, viewed as more heterogeneous products than oil, often exhibited lower degrees of exchange rate pass-through than oil prices.

[17] For raw-material imports, in 5 (4) of 22 countries we see statistically different coefficients on price sensitivity to exchange rates in the short run (long run). For nonmanufactured products the number is 2 (4) of 22.

TABLE 4.—PASS-THROUGH PARAMETER STABILITY—DISAGGREGATED PRICE SERIES

Test	Food	Energy	Raw Materials	Manufacturing	Nonmanufactured
Chow test:					
Short-run instability	3	2	3	3	2
Long-run instability	2	0	0	1	1
Hansen test:					
Short-run instability	2	3	3	4	3
Long-run instability	0	0	0	1	0

Entries in the table show the number of countries for which stability is rejected for each type of import price series. The total number of countries is 20 for disaggregated import price categories.

65% of imports in the OECD countries, with many countries having manufactured products accounting for more than 70% of total imports. At the same time, clear declines in the shares of energy and raw-material products in total imports were almost identical to increases in the shares of manufactured products. This trend continued during the next decade. By 2002, the average share of manufactured imports in total imports for the OECD was 70%. Japan continued to have a lower share of manufactured imports with 46.7%, but this share had more than tripled since 1980.

As reported in table 4, stability tests applied to the exchange rate pass-through rates into these import prices seldom find statistically important evidence of instability. Long-run instability is only observed in 4 of 100 import price regressions according to Chow tests, and in 1 of 100 by the Hansen tests. Instability in short-run pass-through is observed in 13 of 100 cases according to Chow tests, and 15 of 100 cases using Hansen tests. Differences over time in pass-through point estimates at the product level, however, are small compared with differences observed in the aggregated import price series. Many of these instances of product category instability are attributed to data from New Zealand, the Netherlands, and Japan. Together, these observations suggest greater stability in component series than in pass-through elasticities for aggregate bundles of imports.[18]

IV. Understanding the Evolution of Aggregate Pass-through

A. *Theoretical Underpinnings*

Various explanations could be offered for changes over time in the country rates of exchange rate pass-through. In this section we distinguish between these general macro-based explanations and an alternative explanation based on changes over time in the composition of imports. Recall from equation (5) that any import price series is given by $p_t^m = \phi + (1 + \Phi)e_t + c_0 y_t + c_1 w_t^x$. This equation is derived directly from a first-order condition of a firm, and it holds at the individual-product level. In the previous section we used this equation as a justification for the estimation of a pass-through rate for the country using an aggregate import price series. Obviously, this aggregate import price is composed of a weighted average of industry-specific import price indices. If N products are within a country's import bundle, we can rewrite equation (5) for an aggregate index as

$$p_t^m = \sum_{i=1}^{N} \alpha_i \cdot \phi_i + \sum_{i=1}^{N} \alpha_i \cdot (1 + \Phi_i) \cdot e_t + \sum_{i=1}^{N} \alpha_i \cdot mc_t^{i,x}, \tag{9}$$

where α_i represents the weight of any product category i in a country's import bundle. The short-run aggregate pass-through β and changes in it then can be expressed as

$$\beta = \sum_{i=1}^{N} \alpha_i \cdot (1 + \Phi_i), \tag{10}$$

$$\Delta\beta = \sum_{i=1}^{N} \Delta\alpha_i \cdot (1 + \Phi_i) + \sum_{i=1}^{N} \alpha_i \cdot \Delta\Phi_i. \tag{11}$$

Equation (11) states that changes in aggregate pass-through can arise from changes in the weights of different types of products in the overall import bundle, or from changes over time in the markup sensitivities to exchange rates for particular industries.

We can easily nest in this model the macroeconomic hypothesis formulated in the pass-through macroliterature (Engel, Devereux, Taylor) by specifying this markup response as having an industry fixed effect related to the industry's competitive conditions and a time-varying component related to macroeconomic variables:

$$\Phi_i = \mu_i + \mu X_t, \qquad \text{so that} \quad \Delta\Phi_i = \mu\, \Delta X_t. \tag{12}$$

Combining equations (11) and (12), we have

$$\Delta\beta = \sum_{i=1}^{N} \Delta\alpha_i \cdot \Phi_i + \sum_{i=1}^{n} \alpha_i \cdot \mu\, \Delta X_t. \tag{13}$$

Equation 13 states that the aggregate import-price pass-through can change because of the import composition effect and because of the effects of macroeconomic conditions on markups.

[18] Instability tests were also performed on the energy import price regressions bilaterally estimated against dollar exchange rates. There is essentially no evidence of instability in these relationships (2 rejections in 42 cases).

TABLE 5.—MACROECONOMIC VARIABLES VERSUS COMPOSITION AS DETERMINANTS OF PASS-THROUGH CHANGES OVER TIME: TIME SERIES PANELS

	Short-Run Pass-Through (Log Levels)			Long-Run Pass-Through (Log Levels)		
Estimation Method	Weighted Least Squares	Weighted Least Squares	Instrumental Variables	Weighted Least Squares	Weighted Least Squares	Instrumental Variables
Time dummies	√	√	√	√	√	√
Money	0.473		0.600	0.238		−5.221
	(1.156)		(5.035)	(1.931)		(8.878)
Inflation	0.738	0.223	8.265	−0.294	0.217	−5.221
	(2.252)	(1.960)	(9.881)	(3.958)	(3.268)	(15.30)
Exchange rate volatility (×100)	0.467	−1.146	−0.110	−1.272	−1.602	−3.311
	(1.836)	(1.825)	(2.236)	(3.564)	(3.316)	(4.040)
Trade Imputed Elasticity	0.934**	0.945**	1.386***	1.053***	1.146***	1.961**
	(0.476)	(0.485)	(0.376)	(0.545)	(0.310)	(0.671)
Real GDP	−0.025	−0.024	−0.017	0.010	0.038	0.059
	(0.024)	(0.021)	(0.028)	(0.036)	(0.035)	(0.041)
Adj. R^2	0.04	0.05	0.02	0.03	0.02	0.03
Adj. R^2 from specification with only macrovariables	−0.03	0.00		−0.11	−0.07	
Adj. R^2 from trade-imputed elasticity only	0.06			0.08		
No. of obs.	62	62	45	67	67	45

***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Reported regressions exclude country dummies but include time dummies.

B. *Import Composition versus Macrovariability as Determinants of Evolving Pass-through*

Aggregate pass-through elasticities, import composition, and macroeconomic ("exogenous") variables over the full period are not representative of behavior over shorter intervals. Consequently, to test the type of relationship given by equation (13), we split the full sample period into four subperiods: 1975:1 to 1981:4, 1982:1 to 1988:4, 1989:1 to 1995:4, and 1996:1 to 2003:4. For each subperiod, we run a first-stage regression of the type shown by equation (7) and generate four estimates of the short- and long-run pass-through elasticities of aggregated import prices for each country. We also introduce a time series panel version of equation (8) as the second-stage specification, with macroeconomic variables measured over the respective subperiods,[19] and add an imputed trade composition variable. The second-stage specification over the estimated elasticities (four per country, 23 countries) takes the form

$$\Delta\hat{\beta}^{j}_{sr \text{ or } lr} = \gamma_1\Delta \ln money^{j}_{t} + \gamma_2\Delta \ln inflation^{j}_{t} + \gamma_3\Delta \ln exchvol^{j}_{t} + \gamma_4\Delta \ln GDP^{j}_{t} + \gamma_5\Delta \ln imputed^{j}_{t} + \gamma_t t. \quad (14)$$

We apply a weighted least squares procedure in order to reduce the importance of the noisier parameter estimates in driving overall conclusions (the weights are the reciprocals of the estimated standard errors for each pass-through). Within this time series panel approach, the second-stage regressions include time dummies in order to allow for other period-specific fixed effects that are not captured by the exogenous right-side variables.

[19] The GDP variable reflects the 1996 U.S. dollar value of each country's GDP in 1978, 1984, 1990, and 1996.

For each country and time period the *imputed aggregate pass-through elasticity* captures the changes in a country's aggregate pass-through elasticity that are attributable exclusively to changes in its composition of imports. The construct uses the time-invariant (full sample period) estimates of pass-through elasticities for each of the five industry groupings for each country. The imputed elasticity is constructed by varying in each period the weights of each type of import in each country's total import bundle. We use as weights the import share values at 1980, 1986, 1992, and 1998. Two further adjustments need to be made to this variable. First, in its computation we use estimated pass-through elasticities for each of the five product categories. Some of the point estimates for these elasticities are outside the interval [0,1] with large standard errors. Given that pass-through elasticities beyond [0,1] are hard to justify, we compute the imputed trade elasticities, restricting the estimated elasticities at the product level to lie within this interval.[20] Second, the imputed trade elasticity variable is likely to be correlated with the error term, because it has been estimated using the full sample period. Therefore, we instrument this variable using the imputed elasticity based on data from the previous period. This variable is highly correlated with the imputed trade elasticity for the period, and is predetermined, making it a valid instrument.

The results from these specifications are reported in table 5. Consistent with Taylor's (2000) arguments, the short-run pass-through is lower when a country achieves lower inflation or less money growth. Lower and more stable monetary conditions induce producers to pass on a smaller percentage

[20] We also estimated the results from this analysis without restricting the estimated elasticities at the product level to lie within the interval [0, 1]. The results in this case were actually stronger than those reported in table 5. The imputed trade elasticity was always highly significant and had greater explanatory power than the results reported in table 5.

of cost shocks into final-goods prices. These results, however, are never statistically different from 0. Exchange rate volatility is highly noisy and does not have any clear effect on pass-through rates. Finally, the imputed measure of pass-through elasticity due to the evolution of the composition of country import is always positive and statistically significant.

Despite the statistical significance of inflation in these specifications, the included macroeconomic variables account for a negligible amount of the variation over time in pass-through elasticities across countries. The joint explanatory power that these macrovariables have in explaining the evolution of pass-through is basically zero (the adjusted R^2 statistic is negative). F-tests cannot reject the hypothesis that these macrovariables have no explanatory power for long-run pass-through rates across the OECD country sample.

Common time dummies, macrovariables, and imputed trade shares explain approximately 30% of the observed differences over time in the short-run pass-through elasticities of countries. Almost all of the explanatory power of the regressions comes from the imputed trade elasticity variables, even though our composition arguments have been made with only the coarsely disaggregated series that are available in the import price data. Trade composition effects are the clearly dominant explanations for movements over time in the short-run and long-run sensitivity of import prices to exchange rates.

Further evidence for the role of the imputed measure comes from direct tests against the changes observed in the actual pass-through estimates for the sample of 20 countries for which comparisons are possible. The imputed measure generates declines for 21 of the 27 cases where declines were observed in the actual data. The imputed measure generates pass-through increases in 9 of the 14 cases where increased pass-through was observed in the actual data.

The main reason for this decline in the aggregate import price elasticity is the decline in the relative weight in overall imports of energy and raw materials. These are the two products for which the import price elasticities were often highest. According to this calculation, the aggregate pass-through elasticity for the United States would have declined from 0.36 to 0.27 between 1980 and 2002 (a 25% decline) solely due to the change in the product composition of imports. For Italy, the decline would have been of a larger absolute magnitude, from 0.86 to 0.57.

V. Conclusions

In this paper we have provided cross-country, time series, and industry-specific evidence on the pass-through of exchange rates into import prices across a large sample of OECD countries. As a cross-country average, import prices in local currencies reflect 46% of exchange rate fluctuations in the short run, and nearly 65% over the long run. By contrast, exchange rate pass-through into U.S. import prices is approximately 23% in the short run and 42% over the long run. For the OECD as a whole, partial pass-through is overwhelmingly the best description of import price responsiveness shortly after an exchange rate movement. In the longer run, pass-through elasticities are closer to 1, although complete pass-through or producer-currency pricing is still rejected for many countries. Macroeconomic variables play a significant but limited role in explaining cross-country differences in *levels* of pass-through elasticities. Most notably, pass-through into import prices is lower for countries with low average inflation and low exchange rate variability.

Though there is evidence that pass-through rates have been declining over time in some countries, this pattern of pass-through decline has not been a common or robust feature of all OECD countries. Short-run exchange rate pass-through elasticities rise with price inflation (or higher money growth rates). Despite statistical correlations, the quantitative importance of these macroeconomic effects has been small in the OECD. Recent arguments for virtuous cycles between inflation, money policy effectiveness, and pass-through have not been of first-order importance within the OECD countries.

Observed changes in pass-through rates into aggregate import prices more closely reflect changes over time in the composition of import bundles of OECD countries. Pass-through elasticities for manufactured products and food products are generally partial, so that both local-currency price stability and producer price stability are rejected for most countries. By contrast, for countries other than the United States, energy and raw-material imports appear to have pass-through elasticities closer to 1. The shift in the import composition of trade that has taken place over the last two decades toward manufactures and away from energy and raw-material imports has contributed significantly to pass-through declines in approximately half of the OECD countries examined. These types of changes of pass-through into import prices—associated with widespread changes in the composition of industrial activity and trade—are likely to be more durable than those associated with the types of changes in macroeconomic policy environments observed in the OECD in recent decades.

Our findings inform recent discussions of the "exchange rate disconnect" puzzles, wherein exchange rate movements have been shown to have a much smaller effect on consumer prices than would generally be expected. By focusing on the import prices, we have shown that the border prices of goods are in fact very sensitive to exchange rate fluctuations, even for the United States. This evidence leads to the implication that the focus of the disconnect is likely not to depend on whether international prices for goods are set in the currency of the producer or the local currency of the importer. Instead, future research on the transmission and absorption of international fluctuations should focus on the role of the distribution sector and other local value-added

components,[21] which link import prices to prices at the retail level, or other mechanisms that facilitate such apparent domestic insulation.

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DATA APPENDIX

1. OECD Import Price Series

Source: OECD Statistical Compendium. Quarterly time series of import price indices in local currency for 1975:1 to 2003:4. For each country import prices exist for five different product categories: food, energy, raw materials, manufacturers, and nonmanufactured products. The countries for which the data exist are: Australia, Austria, Belgium, Canada, Switzerland, Czech Republic, Germany, Denmark, Spain, Finland, France, United Kingdom, Hungary, Ireland, Italy, Japan, Republic of Korea, Mexico, Netherlands, Norway, New Zealand, Poland, Portugal, Sweden, United States. We use 23 countries for the empirical work, excluding Korea, Turkey, and Mexico for lack of effective exchange rate indices.

2. Effective Exchange Rate Indices

The nominal and real measures are index numbers defined in terms of domestic currency per unit foreign currency. The real effective exchange rate is calculated from unit labor costs for developed countries by the IMF. Code in IFS database: *neu* and *reu.*

3. Money Supply

Defined as money in national currency, seasonally adjusted, with the exception of Sweden and the United Kingdom, for which we have used a somewhat broader definition (money and quasimoney or M0). International Financial Statistics Code in IFS database: 66.

4. Inflation Rate

Annual inflation rates are based on the consumer price indices from the International Financial Statistics. Code in IFS database: 64.

[21] See recent contributions by Burstein, Neves, and Rebelo (2001, 2003) and Corsetti and Dedola (2005).

TABLE A1.—DISAGGREGATED IMPORT PRICE INDICES, FULL DATA SAMPLE

	Food		Energy		Raw Materials		Manufacturing		Nonmanufactured	
Country	Short-Run	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run	Short-Run	Long-Run
Australia	.315†	.350*†	.553	−.688†	.419*†	.430*†	.614*†	.903*	.533*†	.055†
Austria	−.146†	.064	.859	2.235	.102	1.738	.091†	−.302†	.490	1.497
Belgium	.052†	.545	.172	−.700	.619	1.723*	.205†	.425	.142†	.514
Canada	.688*†	.504*†	.294	−.760	.580*†	.473	.785*†	.747*†	.528*†	.040†
Czech Republic	.403*†	.846*	.101	.353	.595*	1.316*	.494*†	.480*†	.340	.838
Denmark	.710*†	.991*	2.237*	3.497	.738*	1.141*	.383*†	.573*†	1.131*	1.613*
Finland	.308	.830	2.427*	1.456	.672	.283	−.046†	.737	1.584*	1.078
France	.806*	1.410*	.405	1.886	—	—	.538*†	.994*	.495	1.273
Germany	.358*†	.482*†	1.610*	2.723*	.939*	1.116*	.335*†	.422*†	1.008*	1.538*
Hungary	.749*	.628*	.247	.886	.421	−.002	.530*†	.787*†	.450	.669
Iceland	—	—	—	—	—	—	—	—	—	—
Ireland	.708*	1.234*	.962*	1.778*	.862*	2.061*	.634*	1.195*	.681*	1.697*
Italy	.638*†	.813*	.603	−.801	1.079*	.764	.576*†	.555*†	.684*	.065
Japan	.269*†	.535*†	.468*†	2.195*	.408*†	.824*	.326*†	.645*†	.413*†	1.471*
Netherlands	.368*†	.538*†	2.097*	2.185	1.402*	1.718*	.232*†	.318*†	1.309*	1.438*
New Zealand	.296*†	.230†	.338	.265	.374*†	−.042†	.186†	.238†	.449	.176
Norway	.582*†	.145†	−.167	−.688	.415	.690	.340*†	.605*	.402†	.074
Poland	.974*	.894	.482	1.990	1.333*	.795	.571*†	.860*†	.814	1.474
Portugal	.313	1.067*	.831	.787	1.082*	1.412*	.614*†	1.016*	.376	.851
Spain	.923*	1.008	.991*	−.005	.608*	1.227*	.604*†	1.055†	.907*	.613
Sweden	.680*	.849*	−.119†	−1.636†	.299†	.111†	.512*†	.661*†	.208†	−.660†
Switzerland	.314†	.529	1.697*	2.939*	.598*†	.795*	.640*†	.838*	1.125*	2.164*†
United Kingdom	.279*†	.517*†	.066†	.391	.387*†	.474*†	.438*†	.456*†	.265*†	.394†
United States	.117†	.209†	.604	.198	.114†	.437*†	.191*†	.443*†	.413†	.333
Average	.461	.655	.746	.805	.617	.848	.430	.616	.623	.784

*Significantly different from 0 (5%). †Significantly different from 1 (5%).