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Trade in Intermediate Goods, Armington Elasticity and Exchange Rate Pass-through

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Trade in Intermediate Goods, Armington Elasticity and Exchange Rate Pass-through

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Abstract

This study analyses the contribution of expanding imports of intermediate goods to the variations in exchange rate pass-through to the prices of imported and domestic goods during the 1990s and 2000s. It differs from previous studies which examine the effect of intermediate goods import on the exchange rate pass-through to export prices. Results show that changes in the Armington elasticity—the elasticity of substitution between imports and domestic products— positively influenced exchange rate pass-through during the period studied. The Armington elasticity subsides as the ratio of imported intermediate goods to total intermediate inputs rises.

Keywords: Armington Elasticity, Exchange Rate Pass-through, International Production Networks, Trade in Intermediate and Capital Goods

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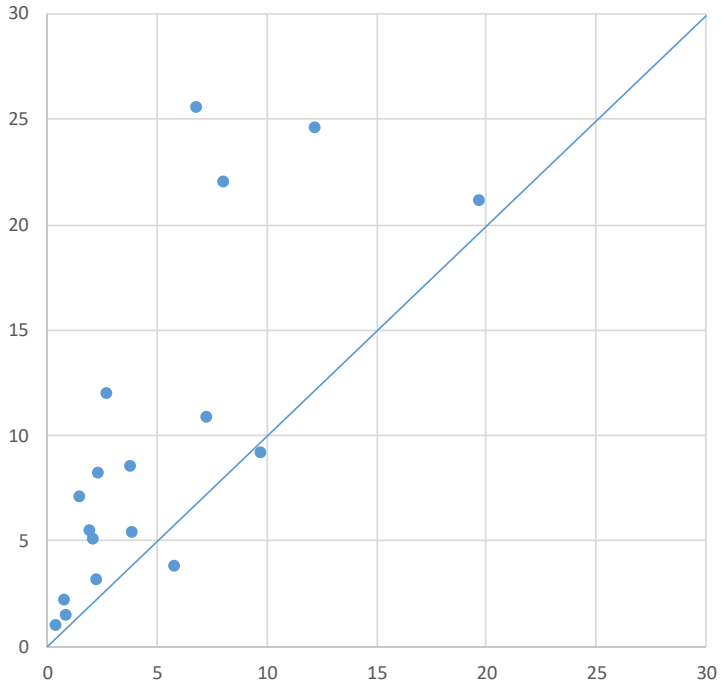
Introduction

Studies of exchange rate pass-through (effects of exchange rate changes on prices) mechanisms pursue three main goals: measuring the degree of pass-through, finding factors that influence it and analyzing how varying degrees of pass-through influence economic dynamics. This study investigates a factor previous studies have ignored, i.e. how the increasing ratio of imported intermediate goods to total inputs influenced the exchange rate pass-through to the prices of imported and domestic goods during the 1990s and 2000s. The inclusion of the factor—and its omission in earlier studies—are significant because during the late 1990s to early 2000s multinational enterprises (MNEs) began to develop international production networks through foreign direct investment (FDI). Their activities generated what is now deemed as vertical intra-industry trade—the creation of global value chains (GVCs) through which firms import intermediate goods to produce finished goods that are themselves re-exported.

Figure 1 depicts inward manufacturing FDI (% of GDP) for the mid-1990s (x-axis) and mid-2000s (y-axis) in 18 countries for which data are available.[1] Almost all countries are distant from the 45° angle in Figure 1, demonstrating that manufacturing FDI, the driving force behind the creation of GVCs, grew rapidly in their economies.

Figure 1. *Inward Manufacturing FDI (% of GDP) for the mid-1990s (x-axis) and mid-2000s (y-axis)*

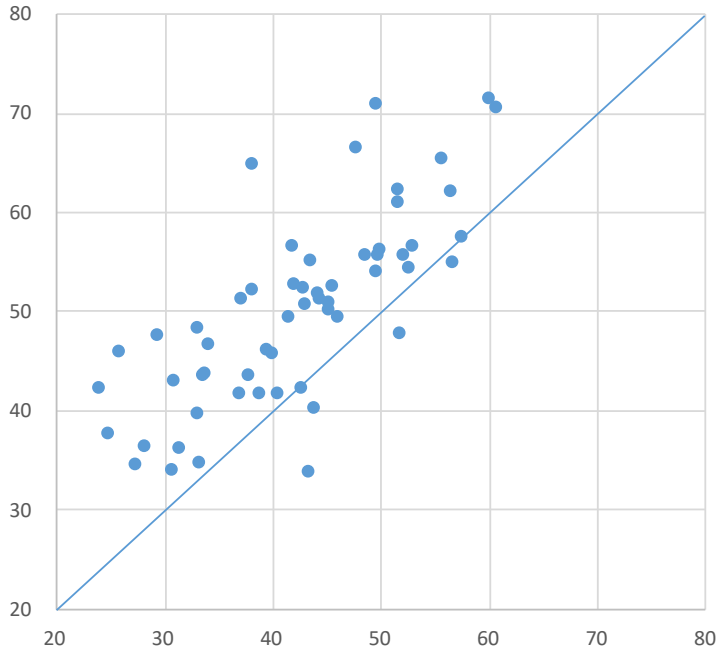


Source: OECD.Stat

[1] Dara source is OECD.Stat

Figure 2 shows GVC participation indices for 1995 (x-axis) and 2009 (y-axis).[2] The GVC participation index is the sum of the forward participation index and backward participation index. The forward index is the share of exported goods and services used as imported inputs to produce other countries' exports. The backward index is the share of imported inputs in the overall exports of a country. The GVC participation index thus indicates the extent to which a country participates in GVCs through which firms import intermediate goods to produce finished goods that are re-exported. Figure 2 demonstrates that GVCs grew during the period.

Figure 2. *GVC Participation Indices for 1995 (x-axis) and 2009 (y-axis) for 57 Economies*



Source: OECD-WTO Trade in Value Added (TiVA) database

Regarding the influence of varying degrees of pass-through on economic dynamics, recent studies have investigated the influences of pass-through by expanding international production and vertical international trade. Shi and Xu (2010) showed that following terms-of-trade shocks or non-traded productivity shocks, exchange rate pass-through to input affects the macro-economy more than its pass-through to prices of finished goods. Compared with cases of full exchange rate pass-through, delayed pass-through to input prices generates greater welfare loss than delayed pass-through to finished goods prices.

Some studies have examined the factors influencing exchange rate pass-through also from the perspective of international production and vertical international trade. Amiti et al. (2014) and Bernini and Tomasi (2015) revealed the relation between imported inputs and exchange rate pass-through to export

[2] Data source is OECD-WTO Trade in Value Added (TiVA) database.

prices. They found that the use of imported intermediate inputs enables exporters to insulate them from the effect of exchange rate fluctuations on exports. An appreciation of the exchange rate causes the price of the product (denominated in the importer's currency) to rise. However, because the exporters depend on imported intermediate goods for their production, it may be beneficial for them to keep the prices low. This intermediate imports channel arises because changes in exchange rate affect prices of imported intermediate goods and the import prices of exported finished goods with opposite signs.

Unlike previous studies, we analyze the contributions of imported intermediate goods on exchange rate pass-through to prices of imported and domestic goods. This is the first study to analyze that relationship. Blonigen and Wilson (1999) note that MNEs prefer to use inputs from their parent country in their offshore production activities. This bias could lower the elasticity of substitution (EOS) between imported and domestic goods (Armington elasticity) in MNEs' host countries.[3] Kardasz and Stollery (2001) investigate Canadian manufacturing and demonstrate theoretically and empirically that Armington elasticity was a decisive factor in exchange rate pass-through to import and domestic prices.

This paper's contribution is to confirm empirically the contributions of expanding international production on exchange rate pass-through to prices of imported and domestic goods. The Armington elasticity, which we can theoretically derive as a factor to change exchange rate pass-through, is regarded as a deep parameter (exogenous variable) and thus we can clearly understand the causal correlation between the elasticity and exchange rate pass-through.[4] Analysis reveals that the elasticity declines in countries where imports of intermediate rise relative to domestically produced goods. The average ratio of imported intermediate goods (manufacturing parts and accessories) to total intermediate inputs among countries in this study rose from 2% during the mid-1990s to 15% during the mid-2000s. Moreover, the ratio of imported intermediate goods to total intermediate inputs and the relative size of inward manufacturing FDI, a proxy of MNEs inflows (% of GDP) are positively correlated for sample countries in the 2000s and this relation was not confirmed in the 1990s.

This study proceeds as follows. Section 2 describes the relation between exchange rate pass-through and Armington elasticity and analyses it empirically

[3] This study examines macro-based Armington elasticity reflecting total import. The average ratio of imported intermediate goods to total imports among countries in this study amounts to 65% during the 1990s and 2000s (data source is the United Nation Commodity Trade Statistics Database, classification of Broad Economic Categories). When capital goods are included, the ratio goes up to 82% during the same periods. Capital goods are also necessary for MNEs to produce their products in host countries and MNEs prefer to use them from their parent country as is the case with intermediate goods.

[4] The Armington elasticity is usually considered to differ from one industry to another. In this study macro-based Armington elasticites for different countries are estimated as we analyze the elasticity's contribution to not industrial but macro exchange rate pass-through. In this case macro elasticity is regarded as an 'averaged elasticity' which reflects a different industrial structure for each country.

for the 1990s and 2000s. Section 3 discusses the factors underlying Armington elasticity, focusing on expanding trade in intermediate goods. Section 4 concludes.

Mechanism of Pass-through Changes and Armington Elasticity

Changes in exchange rate pass through to import and domestic prices via two channels. A direct effect arises because exchange rates alter production costs denominated in domestic currency for foreign producers directly. That phenomenon disturbs domestic competition between domestic and foreign goods and might alter prices of domestic and/or imported goods. An indirect effect arises because exchange rates determine the prices of both domestically-produced and imported intermediate goods used by domestic producers.

Kardasz and Stollery (2001) decompose the total effect of changes in exchange rates (*e*) on prices of domestically produced and imported goods as

$$\alpha_{ie} = \alpha_{im}\frac{dlnc_m}{dlne} + \alpha_{id}\frac{dlnc_d}{dlnp}\frac{dlnp}{dlne}$$

for $i = d$ (domestic goods), m (imported goods)
where p is the combined average price of both domestic and imported intermediate goods used by domestic producers. *cd* and *cm* are the marginal costs of domestic and foreign products denominated in domestic currency, respectively. αim and αid are cost pass-through elasticities (effect of cost changes on import and domestic prices). αie is the exchange rate pass-through elasticity for prices of domestic and imported goods. The direct effect is the first element on the right side of the equation, and the indirect effect is the second.

Assuming that the marginal cost of foreign goods is exogenous, *cm* can be proportional to *e* (i.e. *dlncm /dlne* = 1). With this modification, the pass-through of fluctuating exchange rates to import and domestic prices is analyzed using two types of cost pass-through (αim and αid) and two elasticities (*dlncd /dlnp* and *dlnp /dlne*).

Kardasz and Stollery (2001) replace cost pass-through with Armington elasticity as per the Slutsky equation. According to the Slutsky equation, the value of the Marshallian own-price elasticity of demand, an essential explanatory variable for cost pass-through,[5] equals the Hicksian or compensated demand elasticity between imported and domestic goods (Armington elasticity) plus the ratio of imported goods in total expenditures times the income elasticity of demand. *dlncd /dlnp* in the elasticities above can be replaced by the percentage of total cost attributable to expenditures on intermediate goods.

[5] Consider a monopolistic firm facing decreasing demand and a constant marginal cost of production, *c*. The monopolistic firm's first-order condition is $pi[1\text{-}1/\varepsilon ii(pd, pm, y)] = ci$ (p is price and y is income and ε is the Marshallian own price elasticity of demand and $i = d$ (domestic goods), m (imported goods)). According to this condition, the proximate determinant of the cost pass-through elasticity is the Marshallian own price elasticity of demand.

Our equation for exchange rate pass-through contains three explanatory variables: (1) Armington elasticity, (2) the ratio of expenditures on imported goods and (3) the cost share of intermediate goods multiplied by the exchange rate pass-through for intermediate goods (*dlnp /dlne*).[6] Variables (1) and (2) are introduced from the Slutsky equation. Variable (3) equals *dlncd* / *dlnp** *dlnp* / *dlne* in the pass-through equation.

In what follows, we calculate exchange rate pass-through, Armington elasticity and other variables, including those from the pass-through equation, for the 1990s and 2000s. These two periods are selected because GVCs grew rapidly in the latter period as mentioned in the introduction. We then estimate the equation to determine factors influencing changes in pass-through during both periods.

First, we estimated exchange rate pass-through using a VAR model following Ito and Sato (2007). It includes six variables: oil price, GDP gap, money supply (M1), nominal effective exchange rate (NEER), import prices and consumer prices. Data are seasonally adjusted and converted into the rate of change from the previous period.[7] To mimic structural shocks, we employed a Choleski decomposition of a variance-covariance matrix of the reduced form VAR residuals. The six-variable shocks are identified via Choleski decomposition in which oil price comes first followed by the GDP gap, M1, NEER, import prices and consumer prices. Exchange rate pass-through is the ratio of the price response to the NEER shock to the corresponding response of NEER to its own shock. In estimating a VAR, we selected the number of lags based on the Akaike information criterion. Accumulated responses of the indicated variables to a specific shock span six months.

Next, we estimated macro-based Armington elasticity for each country per Heathcote and Perri (2002), who derive equilibrium relations among percentage deviations from steady state real exchange rate, deviations from steady state output in home country and trading partners and net exports as a fraction of GDP. Armington elasticity can be calculated from the coefficients obtained by estimating the equation for equilibrium relations.[8]

We prepared all variables necessary to estimate the pass-through equation above for the 1990s and 2000s as period averages. We estimated using data spanning 1990–1999 for the 1990s and 2000–2012 for the 2000s. Data for estimating pass-through were monthly, and data for estimating Armington elasticity were quarterly.[9]

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[6] The exchange rate pass-through for intermediate goods is estimated by regressing the first difference in the logarithm of the price of intermediate goods against the first difference in the logarithm of the nominal effective exchange rate, detrended GDP (GDP gap) and its own lags (Kardasz and Stollery, 2001).

[7] VAR analysis enables us to examine domestic price responses to other macroeconomic shocks as well as exchange rate shocks.

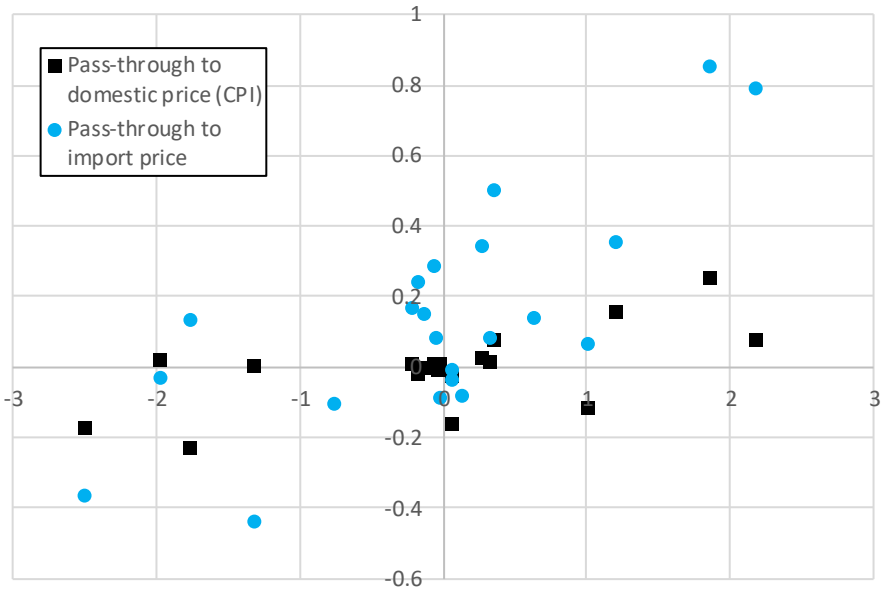
[8] For the derivation of equilibrium relations, see Appendix A of Heathcote and Perri (2002).

[9] The data include the following 32 countries: Australia, Belgium, Brazil, Canada, Colombia, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Ireland, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Pakistan, the Philippines, Poland, Portugal, Singapore, Spain, Sweden, Switzerland, Thailand, Turkey, the United Kingdom and the United

Estimation results of exchange rate pass-through for imported (domestic) goods were obtained for 30 (29) countries for the 1990s and 32 (30) countries for the 2000s. For Armington elasticity, the number of estimated countries was 23 for the 1990s and 25 for the 2000s. Variables were not estimated because data were limited and/or because signs of estimated coefficients were inconsistent with theoretical expectations.

Correlation coefficients between macro Armington elasticity and exchange rate pass-through to import and domestic prices are 0.335 and 0.163, respectively, for the 1990s and 0.680 and 0.718, respectively, for the 2000s. All correlations during the 1990s were non-significant. Correlations during the 2000s are significant at 1%.

Figure 3. *Armington and Pass-through Elasticities for Imports and Domestic Goods*



Notes: The horizontal axis indicates changes in Armington elasticities. The vertical axis indicates changes in exchange rate pass-through to different prices during the 1990s and 2000s.

Figure 3 shows relations between Armington and pass-through elasticities for imported and domestic goods. All data are expressed as differences between the 1990s and the 2000s. These two variables exhibit relatively strong positive correlations (coefficients are 0.753 for imported goods and 0.632 for domestic goods and are significant at 1%).

States. We used quarterly data to estimate of exchange rate pass-through for Australia, Hungary, New Zealand, Norway and Portugal due to limited availability of data. Data sources are the CEIC database and OECD STAN Input-output tables.

Table 1. *Determinants of Elasticities of Exchange Rate Pass-through*

	Dependent variables	constant	Armington elsticity	Expenditure share of imported goods	Cost share of intermediate goods * exchage rate pass-through for intermediate goods	Adjusted R^2	No. of countries
(1)	$d\alpha$ de	−0.039	0.047 **	−1.481 *	−0.178	0.31	15
		(−1.12)	(2.31)	(−2.17)	(−0.64)		
(2)	$d\alpha$ me	0.062	0.259 ***	−0.630	−0.539	0.42	17
		(0.55)	(3.78)	(−0.30)	(−0.69)		
(3)	α de (1990s)	0.019	−0.009	0.028	−0.197	−0.03	16
		(0.10)	(−0.55)	(0.11)	(−1.14)		
(4)	α me (1990s)	−0.239	0.005	0.494	−1.322 **	0.22	17
		(−0.55)	(0.13)	(0.90)	(−2.71)		
(5)	α de (2000s)	0.053	0.100 ***	−0.206	−0.212	0.50	18
		(0.28)	(4.52)	(−0.87)	(−0.94)		
(6)	α me (2000s)	1.400 ***	0.214 ***	−1.705 **	1.042 *	0.51	20
		(3.16)	(3.89)	(−3.07)	(2.01)		
(7)	α de (pooling)	−0.040	0.043 *	0.000	−0.279	0.09	27
		(−0.68)	(2.15)	(0.27)	(−1.09)		
(8)	α me (pooling)	−0.101	0.133 ***	0.006 *	0.318	0.20	29
		(−0.77)	(2.79)	(2.03)	(0.56)		
(9)	α de (Fixed effects)	−0.101	0.046	0.003	0.388	0.42	27
		(−1.23)	(1.79)	(1.09)	(0.36)		
(10)	α me (Fixed effects)	−0.249	0.243 ***	0.003	−0.318	0.32	29
		(−1.08)	(3.29)	(0.59)	(−0.33)		

Notes: t-values are in parentheses. *** Indicates 1% significance, ** 5% significance and *10% significance.

Table 1 indicates estimation results of pass-through equations. Rows (1) and (2) are estimations with first-differencing variables. Rows (3) – (6) are cross-section estimations for the two different periods. Rows (7) and (8) are pooling estimations. Rows (9) and (10) are panel fixed-effects model estimations. Results indicate that Armington elasticity is the most important explanation of changes in the pass-through rate.[10]

Mechanism of Changes in Armington Elasticity

MNEs prefer inputs from their parent countries when producing abroad, and their import bias could lower Armington elasticity in host countries (Blonigen

[10] As note in Kardasz and Stollery (2001), it is not possible theoretically to determine the sign of the coefficient of Armington elasticity in the pass-through regression.

and Wilson, 1999). The following discussion examines trade in intermediate goods and changes in Armington elasticity.

The correlation to be checked first is that between macro Armington elasticity and the ratio of imported manufacturing intermediate goods (manufacturing parts and accessories) to total intermediate inputs.[11] As mentioned in the introduction, the ratio of imported intermediate goods to total intermediate inputs and the relative size of inward manufacturing FDI (% of GDP), the driving force behind the creation of GVCs, are positively correlated for sample countries in the 2000s and this relation was not confirmed in the 1990s.[12] Correlation coefficients between the two variables are −0.455 (significant at 5%) for the mid-1990s and −0.390 (significant at 10%) for the mid-2000s. If all data are expressed as differences between the 1990s and the 2000s, the correlation is −0.473 (significant at 5%).

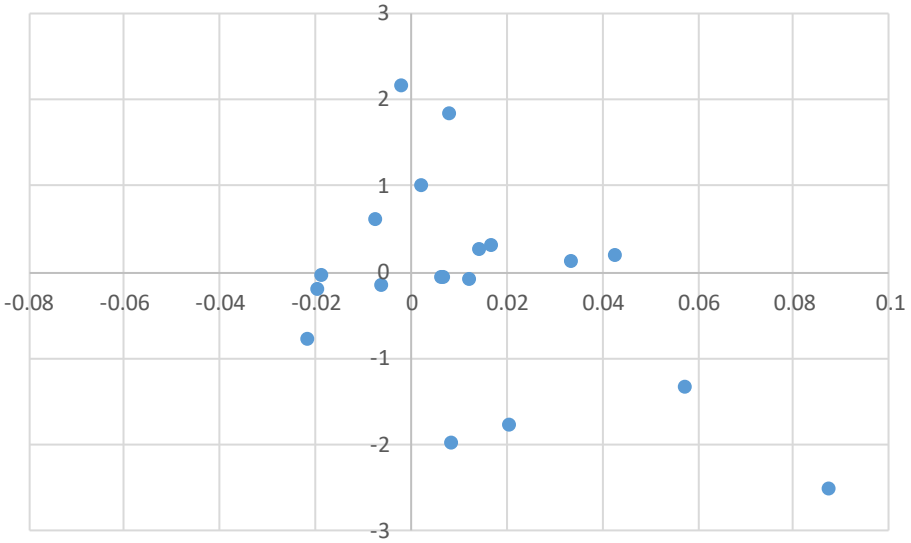
It is not only intermediate goods but also capital goods (production equipment) which are exchanged internationally among international production networks. Takeuchi (2011) analyzed trade in capital goods and synchronization of business cycles between advanced and developing economies during the 2000s and finds that Armington elasticity diminished for both groups as trade in capital goods swelled, and that synchronization increased. We changed the variable import share to the ratio of imported intermediate and capital goods to total intermediate and capital goods used in each sampled country. We then compared the new import ratio and Armington elasticities. Correlations are close (−0.452 for the 1990s, −0.395 for the 2000s and −0.461 for the difference between periods).[13]

[11] Data for import shares are from OECD STAN Input-Output Tables. Manufacturing includes 23 sectors (industry code No. 15-37).

[12] Correlation coefficients between the ratio of imported intermediate goods to total intermediate inputs and the relative size of inward manufacturing FDI are 0.29 for the mid-1990s and 0.61 for the mid-2000s (significant at 1%).

[13] The effects the location of MNEs for final consumption has on Armington elasticity could differ from those intermediate and capital goods imported by MNEs have on the elasticity (Blonigen and Wilson, 1999). The enlarged presence of MNEs in host countries may blur consumers' distinctions between imported and domestic goods and reduce product differentiation, suggesting higher Armington elasticity. For example, location of some operations in the importing country by MNEs may reduce transaction cost of import purchases, such as the ability to receive adequate after-sales service. This hypothesis cannot be verified here because our data cannot distinguish locally produced from MNE-produced and/or -imported consumer goods.

Figure 4. *Armington Elasticity and Share of Imports in Total Demand for Intermediate and Capital Goods Employed in Production*



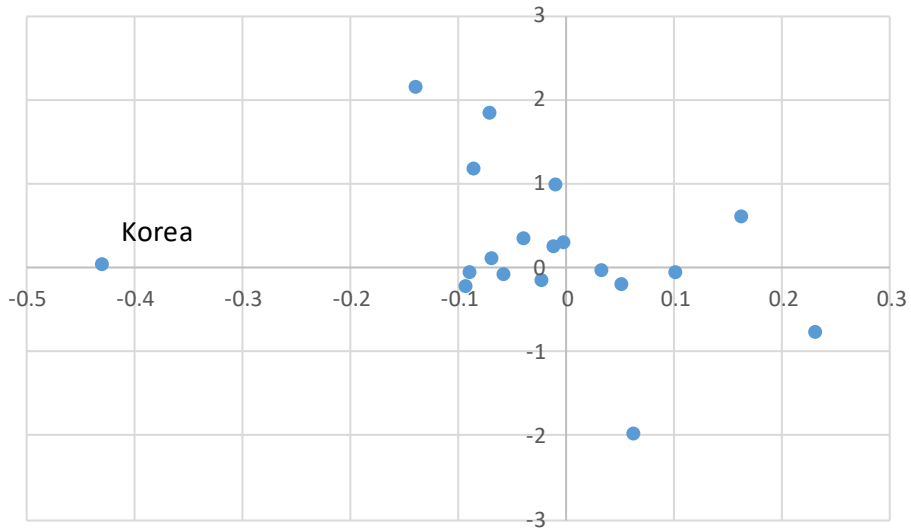
Notes: The horizontal axis indicates changes in the share of imports in total demand for intermediate and capital goods. The vertical axis indicates changes in Armington elasticities during the 1990s and 2000s.

Figure 4 depicts the relationships between these two variables as the difference between the two periods. Figure 4 shows that, for 13 of 19 sampled countries, the ratio of imported intermediate to total intermediate inputs rose during the 1990s and 2000s (dots to the right of the x-axis). Correlation between variables is negative.

Blonigen and Wilson (1999) also focus on product differentiation and confirm a significant negative correlation between the ratio of imports from developing countries and Armington elasticity across U.S. industrial sectors. The greater the share of goods imported from developing countries to the total supply, the greater the product differentiation between U.S. domestic and imported goods, thus lowering Armington elasticity. The share of trade by developing countries in total world trade escalated during our examined period, and increasing imports from developing countries could affect Armington elasticities.

With Brazil, Poland and Hungary excluded from the sample because the IMF categorizes them as emerging and developing economies, we checked the correlation between Armington elasticities and the share of imports from developing countries among total imports for the remaining developed countries. The expected coefficient is negative; actual coefficients are 0.255 for the 1990s and −0.028 for the 2000s. If data are expressed as differences between the two periods, the correlation is −0.331. These correlations are not statistically significant.

Figure 5. *Armington Elasticity and the Income Deviation against Exporting Countries*



Notes: The horizontal axis indicates changes in the income deviation against each exporting country. The vertical axis indicates changes in Armington elasticities during the 1990s and 2000s.

Product differentiation also can be measured by differences in national income between importing and exporting countries. Thus, we calculated the weighted average income of exporting countries in each sampled country for the 1990s and the 2000s. Export values are used as weights. Next, we calculate the absolute rate of deviation between the weighted average income of exporting countries and the importing country's income.

Figure 5 indicates the relationship between Armington elasticity and the degree of income deviation against each exporting country. All data are expressed as differences between the 1990s and 2000s. Korea is an outlier. Other samples show expected negative correlations (coefficient is −0.488 and significant at 5%).[14]

[14] The ratio of weighted average income of exporting countries to Korea's income decreases because Korea's income accelerated to the level of Japan's during the 1990s and 2000s even though the ratio of Japanese imports to total imports in Korea fell from 17.7% in 1998 to 10.5% in 2015. During that period, China replaced Japan as Korea's major trade partner and its share of imported goods rose from 7.9% to 20.6%. 45% of Korea's imports from China were capital goods (excluding transport equipment) and their parts and accessories (code No. 4 in the United Nations Commodity Trade Statistics Database, classification of Broad Economic Categories). During the 1990s, Korea depended on capital goods imported primarily from Japan to produce domestic output. That is, Armington elasticity changed little from unchanged dependence on imported capital and related intermediate goods during the 1990s and 2000s.

Conclusion

This research has revealed factors that influence how changes in exchange rates pass through to prices of imported and domestic goods in 32 sampled countries during the 1990s and 2000s. From the perspective of impacts intermediate goods imports have on exchange rate pass-through, it departs from the current stream of literature that is focusing on how expanded trade in intermediate goods affects exported goods. Analysis reveals that changes in the Armington elasticity positively influence exchange rate pass-through. Specifically, it declines in countries where imports of intermediate and capital goods rise relative to domestically produced goods.

During the early 2000s, many economies joined international production networks as host nations for inflows of MNEs and became active in the exchange of intermediate and capital goods. MNEs prefer to use inputs imported from their parent countries. Their import bias could lower Armington elasticity in host countries.

Theoretical and empirical studies typically regard Armington elasticity as a deep parameter and assume it is fixed. We have shown that it changed during the 2000s as international trade became more vertical. The Armington elasticity also substantially influenced exchange rate pass-through. Our findings offer implications for researchers and policymakers.

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