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Abstract: This paper examines the implications of global production sharing for the measurement of price elasticities in international trade using a unique disaggregated dataset relating to US manufacturing imports. It is found that imports of parts and components are remarkably less sensitive to changes in relative prices and, consequently, the sensitivity of aggregate trade flows to relative prices tends to diminish as trade cuts ever more rapidly into the production process. This finding casts doubt on the validity of the conventional approach to trade flow modeling which lumps together parts and components and final goods as a homogeneous product.

JEL Codes: F10, F23, F41

Key words: global production sharing, trade elasticities, import demand function

Global Production Sharing and the Measurement of Price Elasticities in International Trade[1]

1. INTRODUCTION

Global production sharing — the breakup of a production process into vertically separated stages carried out in two or more countries — has become one of the defining characteristics of the nature of world trade over the past few decades.[2] As the scale of activities in a vertically integrated production process expands, so do the opportunities for reducing costs by locating parts of the production process in different countries. This has resulted in a steady rise of trade in parts and components across national borders as a global phenomenon involving countries at varying stages of development. The purpose of this paper is to probe the implications of the growing dichotomy between trade in parts and components and final goods for the measurement of price elasticities in world manufacturing trade.

There is sizeable theoretical literature examining the causes and modalities of global production sharing, and the implications for trade flow analysis and trade policy.[3] The idea that trade in parts and components within global production networks can have an effect on production, prices and trade flows that is different from trade in goods produced in a single country is gaining widespread acceptance. However, applied trade economists have been rather slow to incorporate this new form of international specialization into trade flow analysis, which continues to rely upon the traditional notion that countries trade goods that are produced from start to finish in a single country. Trade flow analysis is still carried out using trade elasticities estimated at highly aggregated levels, grouping parts and components and final goods together.

Our approach is to compare the results of estimating the standard import equation (eg, Houthakker and Magee 1969, Warner and Kreinin 1983) separately for *total* imports, parts and components and final goods using manufacturing import data of the USA. The USA is chosen for the study based on data availability and the role of USA as the single most important player in world trade. Relating to data availability, our foremost consideration here

[1] We are grateful to James Riedel and Tilak Abesinghe for very helpful comments on an earlier version of this paper, and Omer Majeed and Shahbaz Nasir for excellent research assistance.

[2] This phenomenon has also been described as international production fragmentation, vertical specialization, intra-product specialization, slicing the value chain, and outsourcing.

[3] For comprehensive surveys of this literature see Feenstra (2010), Grossman and Rossi-Hansberg, (2008) and Helpman (2006).

is the availability of genuine trade price indices (rather than unit value series) at a sufficiently disaggregated level, covering a reasonable period of time. Unit value indices have well-known limitations as price proxies, particularly for manufactured goods.[4] It is important to emphasize at the outset that the purpose here is to examine the implications of global production sharing for price elasticities of trade estimated using the standard import-demand model, rather than to estimate the best-fit model for explaining trade flows in the presence of global production sharing. Our results provide strong support for the hypothesis that trade in parts and components taking place within global production networks tends to weaken the explanatory power of the standard import demand function.

The paper is structured as follows. Section 2 provides an overview of the process of global production sharing, the resultant dichotomy between trade in parts and components and final (assembled) goods, and the likely implications for the responsiveness of trade flows to changes in relative prices. Section 3 describes the model and data. Section 4 discusses the estimation methodology. Section 5 presents the results. Section 6 concludes.

2. ANALYTICAL CONTEXT

International production sharing is not a new phenomenon.[5] What is new about the contemporary process of global production sharing is its wider and ever increasing product coverage, and its rapid global spread from mature industrial countries to developing countries. With a modest start in electronics and clothing industries in the late 1960s, international production networks encompassing developed and developing countries have gradually evolved and spread to many industries such as sports footwear, automobiles, television and radio receivers, sewing machines, office equipment, electrical machinery, power and machine tools, cameras, and watches. Initially, global production sharing was predominantly a two-way exchange between the home and host countries; parts and components were exported to the low-cost, host country for assembly, and the assembled components were re-imported to the home country to be incorporated in final products. Over the years, production networks have evolved to encompass multiple countries involved in different stages of the production process (Jones 2000, Brown and Linden 2004).

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[4] For details on the US foreign trade database with an interesting comparison of export price indices and unit value indices see Lipsey et al (1991).

[5] By the late 1950s, when national statistical agencies began reporting data disaggregated enough to allow for tentative estimations, machinery components accounted for nearly 15% of the manufacturing exports of mature industrial countries (Calculation based on the data appendix of Maizels 1963).

In a pioneering attempt to quantify production-sharing trade using trade data from Customs records, Yeats (2001) found that parts and components accounted for 30% of total trade in machinery and transport equipment[6] of the OECD countries in 1996, compared to around 15% in the mid-1980s. Following Yeats's approach, but with broader commodity coverage, Athukorala (2011) estimated the share of parts and components in total world manufacturing trade in 2007 at 32.1%, up from 23.6% in 1992. A number of studies have used the input-output technique to measure the degree of dependence of manufacturing production and trade of selected countries on global production sharing (Hummels et al. 2001, Chen *et al* 2005, Johnson and Noguera 2012, Dean *et al* 2010, Koopman *et al.* 2010). Hanson *et al*. (2005) and Burstein *et al* (2008) measure the extent of production sharing using trade flows between US multinational enterprises and their foreign affiliates. All these studies, regardless of the yardstick used, point to the growing importance of production sharing in world trade and increasing cross-border interdependencies in the world economy.[7]

What are the implications of the on-going process of global production sharing for the degree of sensitivity of trade flows to change in international prices relative to domestic prices? In the recent literature, two competing view have emerged on this issue.

One view holds that global production sharing would have increased the sensitivity of trade flows to relative price changes (Obstfeld 2001a and 2001b). The global spread of production processes, so the argument goes, would induce firms to respond swiftly to changes in relative prices (brought about by changes in exchange rates and tariffs) by switching between domestic and imported inputs, shifting tasks across borders, or changing procurement sources of final (assembled) products. Production networks not only open up greater opportunities for shifting production/procumbent sources in line with such price changes, but also act as swift and efficient purveyors of market information among the participants.

The alternative view, which takes a broader perspective of the nature and modalities of global production-sharing based international exchange, holds that global production sharing could in fact weaken the link between international price changes and trade flows for a number of reasons (Jones and Kierzkowski 2001; Jones 2000, Chapter 7; Burstein et al

[6] These are the products belonging to Section 7 of the Standard International Trade Classification (SITC 7). They roughly account for more than one-half of all trade in manufactures.

[7] In addition to these direct quantifications, there are a large number of case studies of the nature and growing importance of production sharing in industries such as electronics and electrical goods, apparel, and motor vehicle. The popular press is also replete with relevant stories. Krugman (2008) and Burstein provide useful summaries.

2008; Arndt 2008;). First, production units of the value chain located in different countries normally specialize in specific tasks which are not directly substitutable for tasks undertaken elsewhere. In other words, different segments of the production process (including final assembly) are differentiated by country of origin. Therefore, the substitutability of parts and components obtained from various sources is rather limited.

Second, setting up of overseas production bases and establishing the services links entail high fixed costs. Once such fixed costs are incurred, relative price/cost changes become less important in business decision making. This may be particularly so when it comes to business dealings with production bases located in developing countries.[8]

Third, global production sharing could weaken the link between the domestic cost of production and export competitiveness. When a firm in a given country is engaged in a particular segment (slice) of a vertically integrated production process, its export profitability depends not only on external demand and the domestic cost of production, but also on supply conditions in other countries supplying parts and components and the bilateral exchange rates between them. Consequently, the change in the price of imported parts and components becomes an important determinant of export profitability, depending on the magnitude of the share of domestic content (value added + domestically produced inputs) in exported goods.

Fourth and related to the first point, changes in exchange rates affect component imports and end-product exports differently. If exports are made with imported components, then exchange rate depreciation (appreciation) in a given country increases (reduces) the domestic currency price of its exports but it also increases (reduces) the home-currency prices of its component imports, reducing (increasing) the overall profitability of exporting compared to a situation where the production is entirely based on locally-procured inputs. This relationship becomes more complicated when parts and components are procured from countries other than the countries for which the end products are destined, and the number of countries involved in the production chain increases (Arndt and Huemer 2007; Amiti et al 2012). In sum, changes in exchange rates have offsetting effects on imports and exports and thus the net effect of exchange rate changes on exports will consequently tend to be weaker than in the standard case of producing the entire product in the given country.

The above consideration suggests that the implication of global production sharing for estimating price elasticity of world trade is very much an empirical issue. However, the issue

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[8] This point is relevant only to vertical specialization within multinational enterprises, not to arms-length value chain slicing. However, the former is by far the dominant force in global production sharing (Chen et al. 2005; Hanson et al 2005).

has not yet been subjected to sufficient empirical scrutiny, in spite of its immense relevance for trade policy and open-economy macroeconomic policy. To our knowledge, so far the only attempt to examine this issue has been the study by Arndt and Huemer (2007). This study examines whether goods flowing within production networks alter the sensitivity of manufacturing trade between US-Mexico bilateral manufacturing trade to changes in the real exchange rate, and home (US) and Mexican GDP. The findings reveal that exports of automotive parts and components do not respond to the real exchange rate and are solely determined by income levels in the two countries. Escaith et al. (2010) present estimates of income elasticity of demand for trade within global value chains for 30 major trading nations through a bivariate model linking imports to income (GDP). Their income elasticity estimates are presumably biased because of the failure to allow for the relative price effect.

3. THE MODEL AND DATA

The standard import demand equation in a panel data setting takes the form:

$$M_{it} = \alpha + \beta_1 Y_t + \beta_2 RPM_{it} + \delta_i + \gamma_t + \varepsilon_{it} \quad (1)$$

where i=1,2,...,N is the product category, t=1,2,...,T is the time unit in quarters and, M is real imports, Y is domestic income (real GNP), RPM = PM/PD is relative import price (import price/domestic producer price), δ_i is product specific effects, γ_t is time-specific fixed effects and ε_{it} is the disturbance term.[9] The three key variables, *M*, *Y*, and *RPM* are measured in natural logarithms so that the coefficients of the latter two variables can be interpreted as income elasticity and price elasticity of import demand.

We estimate equation 1 using a quarterly panel data set put together from electronic databases of the US Trade Commission (data on imports and import prices) and the US Bureau of Labor Statistics (data on domestic producer price indices and GNP). The original data on manufacturing imports available at the five-digit level of the Standard International Trade Classification (SITC) were separated into parts and components and final goods,[10] and

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[9] The time-specific fixed effects are time-varying common shocks to the import demand of all products. In our model, domestic income is invariant across all product groups, and thus captures the time varying common shocks. Therefore instead of time-specific fixed effects, we include a linear time trend and quarterly dummies in the model. This is also desirable given the large number of time periods that our model covers.

[10] The list of parts and components used for this purpose is based on UN Broad Economic Classification (BEC) Registry (available at http:/www. unstats.un.org/unsd/cr/registry). Following Yeats (2001), we separated parts and components (middle products) from the standard intermediate goods based on the detailed commodity nomenclatures given in the BEC directory supplemented with products covered under the WTO Information Technology Agreement. For details on the method data compilation with the list of parts and components, see Athukorala (2010).

aggregated at the 3-digit level for the purpose of the analysis. Domestic price series (available at the 4-digit US Industrial Classification (USSIC) were matched with the SITC 3-digit import price series using the standard SITC-ISIC concordance obtained from the website of the UN Statistical Office. Details on the commodity and time coverage of the data set, together with parts and components shares in each commodity, are given in Appendix Table A-1.

The dataset cover 43 SITC 3-digit products which accounted for nearly 62.5% of total US manufacturing imports during 1990-2007. The data panel is unbalanced: the time coverage of data for individual products varies from 1992Q4 – 2007Q4 to 2003Q4 - 2007Q4. Import demand functions are estimated using data for all 43 products and the sub-category of machinery and transport equipment, distinguishing between parts and components and final imports. We treat machinery and transport equipment separately as a sensitivity check for two reasons: production sharing is heavily concentrated in this product group and the identification of parts and components in machinery and transport equipment trade in the SITC system is considered much more comprehensive compared to the rest of manufacturing trade (Yeats 2001).

The standard activity variable in the import demand equation is domestic income. However we also gross industrial production (*I*) as an alternative activity variable in the import demand equation for parts and components. The data on gross industrial production index are obtained from the online database of US Federal Reserve.

4. **Estimation Methodology**

In experimental runs, the model specified in Equation (1) is estimated using both the random-effects (*RE*) and fixed-effects (*FE*) estimators. The *RE* estimator imposes the restriction that the product specific fixed effects are uncorrelated with the activity variable and relative import price. The FE estimator, on the other hand, provides consistent estimates even when this assumption does not hold. In terms of the robust version of the Hausman test[11] we were able reject the null that RE estimates are consistent.

Given that the USA is a dominant player in world manufacturing trade (accounting for nearly a fourth of total value of world trade), it is quite possible that *M* and *RPM* are jointly determined, leading to a possible reverse causality (Orcutt 1950). Mindful of this

[11] Unlike the standard version, the robust version of the test does not assume that the random effects estimator is efficient and instead uses cluster (product) robust standard errors to calculate the test statistic (Cameron and Trivedi 2010).

issue, we re-estimated the equation using FE- IV (fixed effects – instrumental variables) estimator. The external instrument used is the relative export price index (*RPX*, the US export price divided by the US producer price). *RPX* is a suitable external instrument: in the widely-open US economy import and export prices tend to move closely, but there is no reason to believe that export price directly impact on imports (*M*).[12]

Another methodological issue that needs to addressed in working with macroeconomic panel data with a long time span (t) is the possibility that the FE and FE-IV estimators could yield spurious results if the data are non-stationary (Baltagi 2005). If the variables are co-integrated (that is, the variables share a common stochastic trend), estimation of the static model gives super-consistent results characterized by extremely high *t*-ratios. Even though the coefficients then represent a consistently estimated long-run relationship, inference about their statistical significance is misleading. The issue can be addressed by estimating an ARDL formulation of the model. In addition to providing valid inference about the statistical significance of the variables, this method permits separate estimation of short run and long run relationships (Pesaran and Smith 1995, Pesaran et al 1999, Blackburne and Frank 2007).

We tested for the presence of unit root in the three variables using the Fisher combination test developed by Maddala and Wu (1999) for unbalanced panel data analysis. The results are reported in Table 1. Under the null hypothesis, all data series contain a unit root: while the null cannot be rejected for the level of any variable, it can be rejected for the first difference. Thus there is a strong case for estimating the ARDL formulation of equation (1) with one lag as a robustness check:

$$M_{it} = \alpha_1 Y_t + \alpha_2 RPM_{it} + \alpha_3 M_{it-1} + \alpha_4 Y_{it-1} + \alpha_5 RPM_{it-1} + \delta_i + \gamma_t + \varepsilon_{it} \qquad (2)$$

Simple algebraic manipulation converts the ARDLspecification into the following panel error-correction formulation:

$$\Delta M_{it} = \lambda_1 \Delta Y_{it} + \lambda_2 \Delta RPM_{it} + \mu_i\,(M_{it-1} - \beta_1 Y_{it} - \beta_2 RPM_{it}) + \delta_i + \gamma_t + \varepsilon_{it} \qquad (3)$$

Where, $\mu_i = -\,(1-\alpha_3)$; $\beta_1 = (\alpha_1 + \alpha_4)/(1-\alpha_3)$; $\beta_2 = (\alpha_2 + \alpha_5)/(1-\alpha_3)$

In Equation 3, the βs are the long run elasticities, and μ is the parameter of adjustment towards the long run equilibrium. If the adjustment parameter is negative and statistically significant, there is evidence of a long-run co-integrating relationship amongst the variables.

[12] In this we follow Feenstra (2010) who uses export prices as one of the explanatory variables in a model designed to explain domestic-market price of imported manufactured goods.

Table 1: Maddala and Wu (1999)'s Fisher Tests for Unit Root

	Level	First Difference
Total Imports total	71.98 (0.90)	2684.95 (0.00)
Final	61.18 (0.90)	2249.38 (0.00)
Parts and components	72.59 (0.33)	2052.90 (0.00)
Income	2.81 (1.00)	1607.41 (0.00)
Gross Industrial Production	9.36 (1.00)	3062.79 (0.00)
Relative Price	60.82 (0.99)	2275.58 (0.00)
Machinery and transport equip total imports	39.97 (0.79)	1370.37 (0.00)
Final	29.07 (0.79)	936.91 (0.00)
Parts and components	29.29 (0.96)	1282.12 (0.00)
Income	1.53 (1.00)	876.77 (0.00)
Gross Industrial Production	3.18 (1.00)	362.94 (0.00)
Relative Price	45.63 (0.57)	1297.59 (0.00)

Note: H_0: All panels contain a Unit Root. Chi-squared statistic reported along with p-value in parenthesis.

It estimating Equation 3 it is important to take into account potential parameter heterogeneity across different products (Blackburne and Frank 2007). In experimental runs, we used the three alternative estimation methods: the Dynamic Fixed Effects estimator (DFEE), the Mean Group estimator (MGE), and the Pooled Mean Group estimator (PMGE). DFEE imposes the highly restrictive constraint that all parameters except those relating to the product specific effects are homogenous. DFEE is the most efficient in case the constraint holds, but inconsistent otherwise. PMGE allows the short run coefficients to differ but constrains the long run coefficients to be homogenous for all product groups (Pesaran, Shin and Smith (1999). MGE assumes complete heterogeneity, that is, it imposes no constraints on any of the parameters (Pesaran and Smith 1995). This in effect would mean estimating a separate equation for each product group and then simply averaging the regression coefficients. Thus MG is consistent but the least efficient. The validity of the constraints — the difference in estimates using the alternative estimators — can be tested using a standard Hausman test. In our case there is no evidence that the estimates from DFEE systematically differ from the less restrictive PMGE and MGE. Therefore DFEE is preferred on efficiency grounds. Most of the empirical literature that estimates error correction representations similar to equation (3) rejects the null that DFE is consistent (Freeman 2000, Bassanini and Scarpetta 2002, Martinez-Zarsozo and Bengochea-Morancho 2004, Goswami and Junayed 2006, Frank 2009 etc). However our investigation differs from previous applications of this methodology in that the cross-section here consists of product types within a given country rather than different countries or states.

5. RESULTS

The FE-IV estimates of Equations (1), excluding the quarterly dummies and the time trend, are reported in Table 4. For the purpose of comparison FE estimates are also reported in Appendix Table A-2. Both the FE-IV and FE results are strikingly similar indicating that endogeneity of *RPM* variable is not a major issue. The following discussion, therefore, focuses on FE-IV estimates which are methodologically superior.

Table 2: Import Demand Functions - Fixed Effects IV Estimates

	Total	Parts and Components	Final
(1) Total manufactured imports			
Relative Price	-1.50*** (0.44)	-0.89** (0.39)	-2.85*** (0.66)
Income	2.95*** (0.65)	3.37*** (0.74)	2.39*** (0.87)
R^2(within)	0.84	0.81	0.79
R^2(between)	0.02	0.00	0.00
Quarterly Dummies	Yes	Yes	Yes
Joint Significance of Quarterly Dummies (p-value)	0.00	0.00	0.00
Products	44	34	38
Observations	2490	2009	2104
Relative Export Price (First Stage)	0.82 (0.17)	0.91*** (0.19)	0.87*** (0.20)
(2) Machinery and Transport Equipment			
Relative Price	-1.10** (0.48)	-0.75* (0.46)	-3.14*** (0.41)
Income	3.61*** (0.84)	3.57*** (1.00)	3.03** (1.20)
R^2(within)	0.86	0.82	0.81
R^2(between)	0.00	0.00	0.00
Quarterly Dummies	Yes	Yes	Yes
Joint Significance of Quarterly Dummies (p-value)	0.00	0.00	0.00
Products	24	22	18
Observations	1484	1355	1098
Relative Export Price (First Stage)	0.97*** (0.22)	0.96*** (0.22)	1.18*** (0.20)

Notes: Standard errors clustered by products are reported in parenthesis. All specification include quarterly dummies (with the fourth quarter as the base), a linear time trend and a constant - these are not reported. *Relative Export Price* is the excluded instrument for Relative Price.

***Significant at 1% level. **Significant at 5% level. *Significant at 1% level.

The magnitude of the estimated price elasticity of parts and components is much smaller in magnitude compared to that of final goods for both total manufactured goods and the subcategory machines and transport equipment. In the case of total manufactured goods, the price elasticity of final imports is 2.85 compared to 0.89 for parts and components. The comparable estimates for machinery and transport equipment are 3.14 and 0.75. In both cases, the differences are highly statistically significant (the magnitude of the difference is beyond a ‘three standard errors’ band). The hypothesis that global production sharing tends to increase price elasticity of trade flows by opening up greater opportunities for traders to shift production/procurement sources in line with price changes seems to hold only for assembled final goods.

Finally, the coefficient of domestic income variable (income elasticity of import demand) is highly significant. There is no statistically significant difference among the estimated coefficients for parts and components and final goods for both total manufactured, and machinery and transport equipment. Global production sharing seems to have direct implications only for the estimation of price elasticities in world trade.

Table 3 reports the FE IV estimates for imports of parts and components with gross industrial production as the activity variable. The relative price elasticity of parts and components imports remains similar to earlier estimates. However, the estimated coefficient of gross industrial production is significantly smaller in magnitude compared to the corresponding regressions with domestic income as the activity variable. This may be because the data series of industrial production is much more variable compared to that of domestic income.[13]

Turning to the estimation of the error-correction reparametrization of the dynamic model (Equation 3), DFEE turned out to be our preferred estimator on efficiency grounds based on the Hausman test as explained previously. The estimates are reported in Table 4. The adjustment coefficient is statistically significant at the one-percent level or better with the expected negative sign in all regressions, clearly indicating the presence of a long run co-integrating relationship amongst the variables. The long-run elasticity estimates are generally consistent with the earlier results for the static model. The magnitude of the estimated long-run price elasticity of final goods is greater than parts and components in both cases, and the difference is highly statistically significant (the respective coefficients do not overlap within the ‘three standard error band’). The short-run price elasticity, as expected, is much smaller in magnitude, but not estimated with precision, except for parts and components equation for machinery and transport equipment, which is statistically significant only at the ten percent

[13] The coefficient of variation for gross industrial production is 4.66 compared to 1.82 for domestic income.

level. The estimated income elasticity is highly statistically significant in both the long-run and short-run for total manufactured imports, with the magnitudes in the short-run being significantly lower as expected. However, for machinery and transport equipment the long-run income elasticity of final goods is not statistically significant.

Table 3: Import Demand Functions for Part and Components with alternate activity variable- Fixed Effects IV Estimates

	Total manufactured imports (SITC 5 to 8)	Machinery and Transport Equipment (SITC 7)
Relative Price	-0.89*** (0.37)	-0.75* (0.44)
Gross Industrial Production	1.27*** (0.28)	1.25*** (0.39)
R^2(within)	0.81	0.82
R^2(between)	0.00	0.00
Quarterly Dummies	Yes	Yes
Joint Significance of Quarterly Dummies (p-values)	0.00	0.03
Products	34	22
Observations	2009	1355
Relative Export Price (First stage)	0.91*** (0.19)	0.96*** (0.22)

Notes: Standard errors clustered by products are reported in parenthesis. All specification include quarterly dummies (with the fourth quarter as the base), a linear time trend and a constant - these are not reported. Relative Export Price is the excluded instrument for Relative Price.

***Significant at 1% level. **Significant at 5% level. *Significant at 1% level.

Finally Table 5 reports the DFE estimates for imports of parts and components with the alternative activity variable. The estimated price elasticities remain almost identical. Moreover, similar to the case of the static model, the estimated import elasticity with respect to gross industrial production is significantly lower than the corresponding income elasticity. Interestingly, there is no statistically significant difference between the magnitudes of short run and long run elasticities.

7. CONCLUDING REMARKS

Global production sharing has become a defining characteristic of economic globalization over the past three decades. Consequently, trade in parts and component has been expanding more rapidly than that of conventional final-goods trade. In this paper we have examined the implications of this structural change in world manufacturing trade for the estimating trade elasticities by estimating impost-demand functions for manufactured goods imports to the USA carefully disaggregated into parts and components and final goods.

The findings suggest that parts and components are relatively less sensitive to changes in relative prices. The upshot is that the sensitivity of aggregate trade flows to relative prices tends to diminish as the production processes become even more fragmented across national boundaries. Overall, our results suggest that the expansion of trade taking place within global production networks tends to weaken the explanatory power of the standard import demand function.

Table 4 : Import Demand Functions - Dynamic Fixed Effects Results

	Total	Parts	Final
(1)Total manufactured imports (SITC 5 to 8)			
Adjustment Coefficient	-0.16*** (0.05)	-0.14*** (0.05)	-0.16 (0.03)
Long Run Coefficients			
Relative Price	-1.06*** (0.25)	-0.05 (0.71)	-2.31*** (0.65)
Income	3.41*** (0.68)	3.88*** (1.46)	3.38** (1.43)
Short Run Coefficients			
Relative Price	-0.11 (0.11)	-0.08 (0.10)	-0.05 (0.19)
Income	1.45*** (0.36)	2.14*** (0.42)	1.61*** (0.52)
Number of Observations	2602	2127	2222
Number of Products	44	34	38
Quarterly Dummies	Yes	Yes	Yes
Joint Significance of Quarterly Dummies	0.00	0.00	0.00
Hausman test p-value (PMG versus DFE)	0.99	0.99	0.74
Hausman test p-value (MG versus DFE)	1.00	1.00	1.00
(2) Machinery and Transport Equipment (SITC 7)			
Adjustment Coefficient	-0.13*** (0.04)	-0.07*** (0.01)	-0.16*** (0.03)
Long Run Coefficients			
Relative Price	-1.04*** (0.39)	-0.10 (0.58)	-2.93*** (0.31)
Income	3.71*** (0.90)	4.78* (2.92)	3.80 (2.55)
Short Run Coefficients			
Relative Price	-0.07 (0.10)	-0.12* (0.08)	0.05 (0.23)
Income	2.14*** (0.41)	2.40*** (0.34)	2.54*** (0.67)
Number of Observations	1471	1344	1091
Number of Products	24	22	18
Quarterly Dummies	Yes	Yes	Yes
Joint Significance of Quarterly Dummies	0.00	0.00	0.00
Hausman test p-value (PMG versus DFE)	0.99	0.96	0.77
Hausman test p-value (MG versus DFE)	1.00	1.00	1.00

Note: The Error Correction reparameterization of ARDL(1,1,1) dynamic panel specification is estimated. All specification includes product-specific fixed effects, a linear time trend, quarterly dummies (with the fourth quarter as the base) and a constant – these are not reported. The Hausman test is conducted using the variance-covariance matrix from the efficient model to calculate the chi-squared statistic. Under the null, DFE is consistent and efficient. Standard errors clustered by products are reported in parenthesis.

***Significant at 1% level. **Significant at 5% level. *Significant at 1% level

Table 5: Import Demand Functions for Part and Components with alternate activity variable – Dynamic Fixed Effects Estimates

	Total manufactured imports (SITC 5 to 8)	Machinery and Transport Equipment (SITC 7)
Adjustment Coefficient	-0.14*** (0.06)	-0.07*** (0.01)
Long Run Coefficients		
Relative Price	-0.11 (0.71)	-0.19 (0.55)
Gross Industrial production	1.19*** (0.41)	1.29* (0.78)
Short Run Coefficients		
Relative Price	-0.09 (0.09)	-0.14* (0.07)
Gross Industrial Production	1.22*** (0.14)	1.28*** (0.16)
Number of Observations	2127	1344
Number of Products	34	22
Quarterly Dummies	Yes	Yes
Joint Significance of Quarterly Dummies	0.00	0.00
Hausman test p-value (PMG versus DFE)	1.00	1.00
Hausman test p-value (MG versus DFE)	1.00	1.00

Note: The Error Correction reparameterization of ARDL(1,1,1) dynamic panel specification is estimated. All specification includes product-specific fixed effects, a linear time trend, quarterly dummies (with the fourth quarter as the base) and a constant – these are not reported. The Hausman test is conducted using the variance-covariance matrix from the efficient model to calculate the chi-squared statistic. Under the null, DFE is consistent and efficient. Standard errors clustered by products are reported in parenthesis.

***Significant at 1% level. **Significant at 5% level. *Significant at 1% level.

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APPENDIX

Table A-1: Products Covered in the Estimates of US Import Demand Functions

SITC No.	Commodity	Time-coverage	Composition of total imports[1] (%)	Parts and components[1]	
				Composition (%)	Share in total imports
514	Nitrogen compounds	2001Q407Q4	0.3	0.0	0.0
515	Organic/inorganic compounds	1992Q4-07Q4	1.5	0.0	0.0
541	Medicinal and pharmaceutical products	1992Q4-07Q4	0.6	0.0	0.0
542	Medicaments	1992Q4-07Q4	1.6	0.0	0.0
553	Perfumery, cosmetic/toilet preparations	2003Q4-07Q4	0.3	0.0	0.0
582	Plates, sheets, films etc. of plastics	1992Q4-07Q4	0.4	0.1	9.4
598	Miscellaneous chemical products	1996Q4-07Q4	0.4	0.4	24.6
641	paper and paper boards	1996Q4-07Q4	1.3	0.0	0.0
642	Articles of paper or paperboards	2001Q4-07Q4	0.4	0.0	0.0
695	Machine or hand tools	1990-07Q4	0.4	0.9	59.6
699	Manufactures of base metals	1990-07Q4	1.0	0.7	18.1
713	Internal combustion piston engines	2004Q4-07Q4	1.6	5.7	89.9
714	Engines and motors, non-electric	1997Q4-07Q4	1.1	4.1	100.0
716	Rotating electric plants and parts	1990-07Q4	0.6	2.1	84.0
723	Civil engineering plants and equipment and parts	1990-07Q4	0.6	0.9	38.5
728	other specialised machinery and equipment and parts	1990-07Q4	0.9	1.0	29.1
741	Heating and cooling equipment and parts	1996Q4-07Q4	0.5	1.0	47.4
742	pumps for liquid, liquid elevators and parts	1990-07Q4	0.3	0.8	59.1
743	pumps and compressors and parts	1990-07Q4	0.8	0.9	27.9
744	Mechanical handling equipment and parts	1996Q4-07Q4	0.6	0.7	32.7
745	Non-electrical machinery and parts	1990-07Q4	0.4	0.5	28.1
747	Taps, clocks, valves etc. for pipes, boiler cells etc.	1990-07Q4	0.6	2.2	100.0

752	Automatic data processing machines and units thereof	1990-07Q4	5.3	16.4	80.3
759	Parts and accessories of communication equipment	1990-07Q4	2.8	10.9	99.5
764	Telecom. Equipment n.e.s. and parts	1990-07Q4	4.0	7.9	51.2
771	Electrical power machinery and parts	1990-07Q4	0.7	0.9	33.3
772	Electrical apparatuses for switching/protecting electrical circuits	1990-07Q4	1.4	5.5	98.2
773	Equipment for distributing electricity	1999Q4-07Q4	0.9	3.5	100.0
774	Electro diagnostic apparatus	1996Q4-07Q4	0.4	0.3	18.2
775	Household electrical and non-electrical equipment	1990-07Q4	0.8	0.2	6.2
776	Thermionic, cold cathode or photo-cathode values and tubes	1990-07Q4	3.5	13.6	100.0
778	Electrical machinery and apparatus n.e.s	1990-07Q4	1.6	3.9	61.8
781	Passenger motor cars and other motor vehicles	1990-07Q4	10.8	0.0	0.0
782	Motor vehicles for transport	1993Q4-07Q4	1.6	0.0	0.0
784	Parts & accessories of motor vehicles	1989Q1-07Q4	3.3	12.9	100.0
845	Arties of apparels, of textile fabrics	1992Q4-07Q4	2.1	0.1	0.7
872	Medical/surgical instruments and apparatus	1993Q4-07Q4	0.6	0.0	0.0
874	Measuring,/checking equipments and apparatus n.e.s.	1990-07Q4	1.3	1.0	19.7
884	Optical goods, n.e.s.	1990-07Q4	0.3	0.3	22.4
892	Printed matter	1993Q1-07Q4	0.4	0.1	5.1
893	Articles of plastic n.e.s.	1990-07Q4	1.0	0.0	0.9
894	Bay carriages, toys, games and sporting goods	1990-07Q4	2.3	0.0	0.6
898	Miscellaneous instruments and parts	1990-07Q4	0.6	0.5	23.6
899	Miscellaneous manufactured articles n.e.s	1990Q2-07Q4	0.6	0.1	3.8
			62.5		41.4
	other		37.5		
	Total		100	100	25.9

Source: Compiled from US Trade Commission trade database using the parts and component list from Athukorala (2010)

Table A-2: US Import Demand Functions — Fixed Effects Estimates

	Total	Parts and Components	Final
(1) Total manufactured imports (SITC 5 to 8)			
Relative Price	-1.16***	-0.67*	-2.30***
	(0.23)	(0.36)	(0.74)
Income	3.19***	3.25***	2.74***
	(0.59)	(0.76)	(0.73)
R^2(within)	0.85	0.76	0.80
R^2(between)	0.02	0.01	0.00
Quarterly Dummies	Yes	Yes	Yes
Joint Significance of Quarterly Dummies (p-value)	0.00	0.00	0.00
Products	44	34	38
Observations	2646	2161	2260
'RE versus FE' Hausman Test (p-value)	0.00	0.00	0.18
(2) Machinery and Transport Equipment (SITC 7)			
Relative Price	-1.26***	-0.97***	-3.04***
	(0.27)	(0.23)	(0.41)
Income	3.61***	3.51***	3.10**
	(0.86)	(1.01)	(1.22)
R^2(within)	0.86	0.82	0.81
R^2(between)	0.00	0.00	0.00
Quarterly Dummies	Yes	Yes	Yes
Joint Significance of Quarterly Dummies (p-value)	0.00	0.00	0.00
Products	24	22	18
Observations	1495	1366	1109
'RE versus FE' Hausman Test (p-value)	0.00	0.00	0.28

Notes: Standard errors clustered by products are reported in parenthesis. All specification include quarterly dummies (with the fourth quarter as the base), a linear time trend and a constant - these are not reported. The Hausman test is conducted using the variance-covariance matrix from the efficient model to calculate the chi-squared statistic. Under the null, RE is consistent and efficient.

***Significant at 1% level. **Significant at 5% level. *Significant at 1% level.

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