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## Global Production Sharing and the Measurement of Price Elasticity in International Trade

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ABSTRACT

The implications of global production sharing for the measurement of price elasticity in international trade is examined using a unique dataset relating to manufacturing imports of the USA. There is strong evidence that parts and components, which account for a growing share of manufacturing trade, are remarkably less sensitive to changes in relative prices compared to final goods. This finding casts doubt on the conventional approach to trade flow modelling that treats parts and components and finals goods as a unified product.

*JEL classification*: F10, F23, F4

Key words: trade elasticity, global production sharing, dynamic fixed effect estimator

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# Global Production Sharing and the Measurement of Price Elasticity in International Trade

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HIGHLIGHTS

- Examine the effect of global production sharing on price elasticity of international trade.
- Use a new quarterly panel dataset for manufacturing imports of the USA at the 3-digit SITC level.
- The import demand function is estimated using the dynamic fixed effect estimator.
- Imports of parts and components are found to be insensitive to relative price changes.

ABSTRACT

The implications of global production sharing for the measurement of price elasticity in international trade is examined using a unique dataset relating to manufacturing imports of the USA. There is strong evidence that parts and components, which account for a growing share of manufacturing trade, are remarkably less sensitive to changes in relative prices compared to final goods. This finding casts doubt on the conventional approach to trade flow modelling that treats parts and components and finals goods as a unified product.

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## 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 world trade over the past few decades (Feenstra, 2010; Helpman, 2011). This has resulted in a steady rise of trade in parts and components within global production networks (Athukorala, 2014; Yeats, 2001). This paper examines the implications of the growing dichotomy between trade in parts and components, and final goods for the measurement of price elasticities in manufacturing trade.

Our approach is to compare the results of estimating the standard import equation separately for total imports, parts and components and final goods using manufacturing import data of the USA. The USA is chosen for the study primarily based on data availability. Our foremost consideration here is the availability of genuine trade price (rather than unit value) indexes at a sufficiently disaggregated level, covering a reasonable period of time.[1] Unit value indexes have well-known limitations as price proxies, particularly for manufactured goods (Lipsey et al., 1991).

## 2. Analytical context

What are the implications of global production sharing for the sensitivity of trade flows to change in international prices relative to domestic prices? Two competing view have emerged in the recent literature..

One view holds that global production sharing increases the sensitivity of trade flows to relative price changes (Obstfeld, 2001). The global spread of production processes would induce firms to respond swiftly to changes in relative prices by switching between domestic and imported inputs, shifting tasks across borders, or changing procurement sources. Production networks not only open up greater opportunities for shifting production/procumbent sources in line with such price changes, but also act as swift purveyors of market information.

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

[1] The US Bureau of Labour Statistics (BLS) compiles and disseminates import (and export) price indexes under its International Price Program launched in 1971. These indexes are based on actual transaction prices directly collected from foreign trade markets (BLS, 1997).

Substitutability of parts and components obtained from various sources is, therefore, rather limited. Second, setting up of overseas production bases and establishing the service links entail high fixed costs, making relative price/cost changes less important in business decision making. The canonical example of automobiles illustrates the intuition of this reasoning: consumers have more scope for substitution across finished cars than does a car manufacturer across specialized auto parts.

The above considerations suggest that the implication of global production sharing for estimating price elasticity is very much an empirical issue. To our knowledge, so far the only attempt to examine this issue is Arndt and Huemer (2007). In an analysis of the determinants of bilateral manufacturing trade between the US and Mexico, this study finds that trade in automotive parts and components between the two countries is insensitive to changes in the bilateral real exchange rate.

## 3. The model and data

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

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

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), $\delta_i$ is product specific effects, $\gamma_t$ is time effects and $\varepsilon_{it}$ is the disturbance term. 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 and price elasticities.

The model is estimated using a quarterly panel dataset put together from electronic databases of the US Trade Commission (data on imports) and the US Bureau of Labor Statistics (import price, domestic producer price and GNP). The import data at the 5-digit level of the Standard International Trade Classification (SITC) were separated into parts and components and final goods, and then aggregated at the 3-digit level. Domestic price indexes (available at the 4-digit US Industrial Classification and import price indexes (at the 4-digit level of the Harmonized System) were matched with the SITC 3-digit import price series using standard commodity concordances obtained from the website of the UN Statistical Office.[2]

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[2] For details on the method of separating parts and components from the published trade data see Athukorala (2014). The complete data set and the list of parts and components are available on request.

Details on the commodity/time coverage of the data, and the share of parts and components in each commodity are given in the Appendix. The dataset cover 43 SITC 3-digit products, which accounted for nearly 62.5% of total US manufacturing imports (with parts and components accounting for 41.4% of these products) during 1990-2007. The time coverage of data for individual products varies depending on the availability of data on the price index. The import demand function is estimated using data for all 43 products and the sub-category of machinery and transport equipment, distinguishing between parts and components and final imports. The machinery and transport equipment category is treated separately for two reasons: production sharing is heavily concentrated in this product group and the identification of parts and components in the SITC system is much more comprehensive compared to the rest of manufacturing trade.

## 4. Estimation method

There are three methodological issues that we need to be mindful of in estimating Equation 1. First, since the panel data set has a long time span (t), estimation using the standard panel data techniques could yield spurious inferences if the data series are nonstationary (Baltagi, 2005). Second, import prices are potentially endogenous: given that the USA is a dominant player in world manufacturing trade (accounting for nearly a fourth) it is quite possible that *M* and *RPM* are jointly determined. Third, there is the issue of parameter heterogeneity: the possibility that elasticities might differ across product groups.

We tested for stationarity of the data series using the Fisher combination test of Maddala and Wu (1999), which is applicable to unbalanced panel data. The results indicate that all data series are non-stationary and can be transformed into stationary processes of order 1, or I(1). The model is therefore specified in ARDL form:

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

The error-correction formulation of Equation 2 is

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

In Equation 3, the $\lambda$s are the short run and $\beta$s are the long run elasticities, and $\mu$ is the parameter of adjustment towards the long run equilibrium.[3] A negative and statistically

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[3] Since we work with quarterly data with a large time span (t) relative to the number of products, a linear time trend, instead of time-specific fixed effects ($\gamma_t$), is included to capture the trend element in imports; quarterly dummies are included to capture seasonality in imports.

significant estimate of $\mu$ is evidence of a long-run co-integrating relationship amongst the variables.

Importantly for our purpose, a key desirable property of the error-correction formulation of the model is that 'the second order or endogeneity bias in estimated coefficients is asymptotically negligible due to super consistency' (Banerjee et al. 1993, 176). In our case, asymptotic properties reasonably apply given the large number of observations (around 2500) used in estimation.

To investigate potential parameter heterogeneity we experimented with three alternative methods: the Dynamic Fixed Effects estimator (DFEE), the Pooled Mean Group estimator (PMGE), and the Mean Group estimator (MGE) (Pesaran et al., 1999; Blackburne and Frank, 2007). Based on a comparison using the standard Hausman test, the DFEE was selected as the preferred estimator on efficiency grounds.

## 5. Results

The DFEE estimates of Equations (3), are reported in Table 1. The adjustment coefficient is statistically significant at the one-percent level or better indicating the presence of a long run co-integrating relationship. The magnitude of the estimated price elasticity of import demand for parts and components is much smaller and statistically insignificant compared to final goods of both total manufactured goods and the subcategory of machines and transport equipment. For total manufactured goods, the long-run price elasticity of parts and components is 0.05 compared to 2.31 for final goods. The comparable point estimates for machinery and transport equipment are 0.10 and 2.93, respectively. In both equations, the difference between price and income elasticities is beyond two standard error bands. The short-run price elasticities are also not statistically significant and much smaller in magnitude compared to the long-run elasticities, in both cases.

The income elasticity of import demand is statistically significant, in both short- and long-runs. And there is no statistically significant difference between the estimated coefficients for parts and components, and final goods. Global production sharing seems to have direct implications only for the estimation of price elasticities.[4]

[4] We also estimated the parts and component equation using gross industrial production as an alternative activity variable. The estimated price elasticities were almost identical.

**Table 1** Import Demand Functions - Dynamic Fixed Effects Results[1]

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

Note: 1. Estimates for the quarterly dummies and the time trend are not reported. Standard errors clustered by products are in parenthesis, with the statistical significant of the coefficients denoted as *** 1% ,** 5% and * 10 % .

2. The chi-squared test conducted using the variance-covariance matrix from the efficient model.

## 6. Conclusion

The findings suggest that trade in parts and components are remarkably 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. Thus there is a strong case for taking into account the growing importance of production sharing for world trade in modelling trade flows.

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# Appendix

Products Covered in the Estimates of US Import Demand Functions[1]

| SITC code | Product | Time coverage of import prices | Import composition (%) | Parts and components | |
|---|---|---|---|---|---|
| | | | | Composition (%) | Share in each product (%) |
| 514 | Nitrogen compounds | 2001Q4-07Q4 | 0.5 | 0 | 0 |
| 515 | Organic/inorganic compounds | 1992Q4-07Q4 | 2.4 | 0 | 0 |
| 541 | Medicinal and pharmaceutical products | 1992Q4-07Q4 | 1.0 | 0 | 0 |
| 542 | Medicaments | 1992Q4-07Q4 | 2.6 | 0 | 0 |
| 553 | Perfumery, cosmetic/toilet preparations | 2003Q4-07Q4 | 0.5 | 0 | 0 |
| 582 | Plates, sheets, films etc. of plastics | 1992Q4-07Q4 | 0.6 | 0.1 | 9.4 |
| 598 | Miscellaneous chemical products | 1996Q4-07Q4 | 0.6 | 0.4 | 24.6 |
| 641 | Paper and paper boards | 1996Q4-07Q4 | 2.1 | 0.1 | 0 |
| 642 | Articles of paper or paperboards | 2001Q4-07Q4 | 0.6 | 0.1 | 0 |
| 695 | Machine or hand tools | 1990-07Q4 | 0.6 | 0.9 | 59.6 |
| 699 | Manufactures of base metals | 1990-07Q4 | 1.6 | 0.7 | 18.1 |
| 713 | Internal combustion piston engines | 2004Q4-07Q4 | 2.6 | 5.7 | 89.9 |
| 714 | Engines and motors, non-electric | 1997Q4-07Q4 | 1.8 | 4.1 | 100.0 |
| 716 | Rotating electric plants and parts | 1990-07Q4 | 1.0 | 2.1 | 84.0 |
| 723 | Civil engineering plants, equipment and parts | 1990-07Q4 | 1.0 | 0.9 | 38.5 |
| 728 | Specialised machinery and equipment and parts | 1990-07Q4 | 1.4 | 1.0 | 29.1 |
| 741 | Heating and cooling equipment and parts | 1996Q4-07Q4 | 0.8 | 1.0 | 47.4 |
| 742 | Pumps for liquid, liquid elevators and parts | 1990-07Q4 | 0.5 | 0.8 | 59.1 |
| 743 | Pumps and compressors and parts | 1990-07Q4 | 1.3 | 0.9 | 27.9 |
| 744 | Mechanical handling equipment and parts | 1996Q4-07Q4 | 1.0 | 0.7 | 32.7 |
| 745 | Non-electrical machinery and parts | 1990-07Q4 | 0.6 | 0.5 | 28.1 |
| 747 | Parts of pipes and boilers | 1990-07Q4 | 1.0 | 2.2 | 100.0 |
| 752 | Automatic data processing machines and units | 1990-07Q4 | 8.5 | 16.4 | 80.3 |
| 759 | Parts and accessories of communication equipment | 1990-07Q4 | 4.5 | 10.9 | 99.5 |
| 764 | Other telecom. Equipment and parts | 1990-07Q4 | 6.4 | 7.9 | 51.2 |
| 771 | Electrical power machinery and parts | 1990-07Q4 | 1.1 | 0.9 | 33.3 |
| 772 | Apparatuses for switching/protecting electrical circuits | 1990-07Q4 | 2.2 | 5.5 | 98.2 |

| | | | | | |
|---|---|---|---|---|---|
| 773 | Equipment for distributing electricity | 1999Q4-07Q4 | 1.4 | 3.5 | 100.0 |
| 774 | Electro diagnostic apparatus | 1996Q4-07Q4 | 0.6 | 0.3 | 18.2 |
| 775 | Household electrical and non-electrical equipment | 1990-07Q4 | 1.3 | 0.2 | 6.2 |
| 776 | Thermionic, cold cathode or photo-cathode values and tubes | 1990-07Q4 | 5.6 | 13.6 | 100.0 |
| 778 | Electrical machinery and apparatus | 1990-07Q4 | 2.6 | 3.9 | 61.8 |
| 781 | Passenger motor cars and other motor vehicles | 1990-07Q4 | 17.3 | 0 | 0 |
| 782 | Motor vehicles for transport | 1993Q4-07Q4 | 2.6 | 0 | 0 |
| 784 | Parts & accessories of motor vehicles | 1989Q1-07Q4 | 5.3 | 12.9 | 100.0 |
| 845 | Arties of apparels, of textile fabrics | 1992Q4-07Q4 | 3.4 | 0.1 | 0.7 |
| 872 | Medical/surgical instruments and apparatus | 1993Q4-07Q4 | 1.0 | 0.1 | 0.0 |
| 874 | Measuring,/checking equipment and apparatus | 1990-07Q4 | 2.1 | 1.0 | 19.7 |
| 884 | Optical goods | 1990-07Q4 | 0.5 | 0.3 | 22.4 |
| 892 | Printed matter | 1993Q1-07Q4 | 0.6 | 0.1 | 5.1 |
| 893 | Articles of plastic | 1990-07Q4 | 1.6 | 0.1 | 0.9 |
| 894 | Bay carriages, toys, games and sporting goods | 1990-07Q4 | 3.7 | 0.2 | 0.6 |
| 898 | Miscellaneous instruments and parts | 1990-07Q4 | 1.0 | 0.5 | 23.6 |
| 899 | Miscellaneous manufactured articles | 1990Q2-07Q4 | 1.0 | 0.1 | 3.8 |
| | Total | | 100 | 100 | 41.4 |

Note: 1. Data for the period 1990-2007. The products listed in the tables accounted for 62.5% of total manufacturing imports during this period.

Source: Compiled from the data bases of the US Trade Commission and the US Bureau of Labor Statistics.

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