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Intra-industry FDI and Trade Flows: New Measures of Globalisation of Production

by

David Greenaway, Peter Lloyd and Chris Milner

The Authors

David Greenaway is Professor of Economics in the School of Economics, University of Nottingham, Peter Lloyd is Professor of Economics in the Department of Economics, University of Melbourne, Chris Milner is Professor of International Economics in the School of Economics, University of Nottingham.

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Abstract

Cross-border supply can take two forms: arms-length trade and direct production by a foreign affiliate. Moreover, the two forms of supply may be related: depending on a range of circumstances, trade and foreign direct investment could be substitutes or complements. Irrespective of whether they are substitutes or complements, one can only properly assess the consequences of globalisation when the two are aggregated. We do not, however, have measures for "aggregate" cross-border supply and that is the starting point of this paper. We develop new concepts and measures of extended supply and illustrate their utility by applying them to US bilateral intra-industry supply. Our analysis shows that two-way international production is more important than two-way trade. Our new measures also reveal that levels of two-way interpenetration of markets are even higher than the levels of two-way intra-industry merchandise trade predict. The results point to the importance of measuring globalisation fully and provide a basis for doing so more completely than in the past.

Outline

1 Introduction

It has long been recognised that cross border supply can take two forms: arms-length trade and direct production.[1] In the case of the former, a firm supplies exports to a given foreign market that are then sold on through some supply chain. In the case of direct production, the firm establishes (or acquires) an overseas affiliate to produce the commodity locally and then sell it on.

There is now an extensive literature analysing the choice between supplying a foreign market by exporting or by the establishment of a foreign affiliate, that is, by FDI. This is the analysis of the choice of mode of supply. Much of that literature is concerned with the determinants of FDI in general, and the relationship between trade and direct investment in particular. Following Mundell (1957) it was long thought that trade and direct investment were substitutes – crudely, in a world of differential factor endowments, either factors move or goods move. One by-product of the early literature on intra-industry trade, which is dominated by trade between countries with similar factor endowments, is that this particular proposition has been challenged and many models dating from Agmon (1979) emphasise potential complementarities between trade and FDI. There is now a substantial theoretical literature on trade and investment which has been nicely summarised by Ethier (1994, 1996) and Markusen (1995,1998).

There is also a very substantial empirical literature on the determinants of FDI and of course a parallel one on the determinants of commodity trade. In so far as this addresses the relationship between trade and foreign investment, it typically does so by testing for substitutability or complementarity. This is clearly useful. However, it misses a rather important issue, namely the impact of trade *and* direct investment into different markets, irrespective of whether they are substitutes or complements. The key reason why this issue is missed is an obvious one, there is no widely used measure of "aggregate" supply in a given market, i.e. the aggregation of exports and affiliate production in a given context.

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[1] For the owner of a technology which may be sold in a foreign country, there is a third alternative of licensing another agent of production. This alternative could be defined as the third mode and analysed in the same way but it does not involve production and supply by the owner of the technology and will not therefore figure in our analysis.

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This paper addresses that fundamental issue. It begins by setting out some basic definitions of trade and international production in Section 2 and uses these in Section 3 to develop some new concepts and measures of extended supply. In Section 4 we review a number of complications with applying these new concepts prior to working through a series of applications to US bilateral intra-industry supply in Section 5. Section 6 concludes and suggests some extensions for future research.

2   Defining International Trade and International Production

In the literature on multinational firms, supply through an affiliate is sometimes called "international production". "International production is defined as that production which is located in one country but controlled by a multinational corporation (MNC) based in another". (Cantwell 1994, p.303). Using this terminology we can identify two modes of supply as international trade and international production which together comprise "international supply". In its annual *World Investment Report*, UNCTAD has for some years noted that world production by foreign affiliates exceeds world trade in goods (for example UNCTAD, 1995). Some authors have calculated the ratio of production by foreign affiliates to imports of goods and services in the importing countries (for example Petri, 1997), that is, the ratio of international production to international trade in these markets.

If we take the case of industry i in one country, we can define the relevant variables as follows:

X_i^j = exports (supply) to the foreign country or countries by Mode j = 1,2

M_i^j = imports (supply) to the foreign country or countries by Mode j = 1,2

Let Mode 1 be arms-length trade in goods and Mode 2 be international production. Then, X_i^1 and M_i^1 are exports and imports of goods of country i and X_i^2 and M_i^2 are international production by country i's foreign affiliates and the international production in country i by the affiliates of foreign corporations. These definitions of exports and imports may be applied either to the total trade of a single country with all countries or to bilateral trade between one country and a second country. Initially consider the total trade of a country.

While the aggregation of goods trade and international production was motivated by the analysis of the choice of mode of supply for a foreign investor, X_i^1 includes both exports of

parent foreign-investing companies and exports of non-foreign-investing national companies. Both are part of the supply by Mode 1 from the home country to a foreign market. Similarly, imports include both imports from parent foreign-investing companies and from non-foreign investing companies into a national market.

There are some data relating to the ratio of production by foreign affiliates to imports and exports of goods and services, On the import side, there are measures of (M_i^2 / M_i^1). In Western Europe, the ratio of sales of foreign affiliates to imports of goods and non-factor services in 1994 was 1.22 (UNCTAD, 1997, Table I.3).[2.] In North America, the ratio in 1994 was 1.63. On the export side there are measures of (X_i^2 / X_i^1). In Western Europe, the ratio of sales of affiliates abroad to exports of goods and non-factor services in 1994 was 1.50 (UNCTAD, 1997, Table I.3). In North America, the ratio in 1994 was 2.07.

We can also add the modes of supply from and to country i. This gives:

$$X_i = X_i^1 + X_i^2 \tag{1}$$

$$M_i = M_i^1 + M_i^2 \tag{2}$$

That is, we add exports of goods and international production by MNEs of the same country, and the imports of the goods and the international production of foreign MNEs located in the country. This gives us the aggregate international supply from and to a country. The total flows in both directions may be called simply "exports" and "imports".

These ratios (M_i^2 / M_i^1) and the notions of total supply of "exports" and "imports" are appealing, but there are a number of problems with the definitions of exports and imports by mode. For an "importing" country, one possible objection to the use of these summations is that supply to the country by the mode of a foreign affiliate takes place in the home or importing country and, therefore, employs domestic labour and other factors whereas imported goods do not. For the "exporting" country, the opposite is true. These

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[2.] To compare the shares of the markets located in Western Europe, one needs to exclude that part of the sales of affiliates of MNEs which are exported to third countries. No data is available for individual countries in Western Europe.

two sources of supply may, therefore, have different implications for national income and for employment of factors on both the source country and the country of sale.

One way of overcoming this problem is to define the supply from one country in terms of *value added* by factors owned by residents of the country. In both modes, the value added by factors residing in the country which supplies the goods or services is less than the gross value of output. Foreign affiliates import management and other labour and, conversely, the affiliates in other countries may import labour from the home country, and both import intermediate and fixed capital inputs. What contributes to national incomes in both modes is the value added by residents of the home country. This definition would not involve any double counting or inconsistency. The supply by both modes would be part of national income. From the point of view of international trade statistics, this aggregation has the necessary property that the "exports" of one country are equal to the "imports" of the other country and world "exports" equal world "imports". However, statistics of direct trade are not available on a value added basis. Fortunately, this problem can be overcome by a decomposition of the measures as shown in Section 3 below.

A second problem is that statistics of direct "exports" include goods produced in that country by plants of foreign affiliates. If one is including the production abroad of affiliates of the home country in its exports by Mode 2 $\left(X_i^2\right)$, it is not consistent to include the reverse flow by foreign affiliates in the home country as a part of the national supply.

In principle, this problem can be overcome by defining the supply from one country as the supply by companies owned by residents of the country, that is, the *nationality* of the company supplying the goods or services. Julius (1990, chapter 4) suggested a redefinition of world exports and imports of merchandise goods on the basis of the nationality of the producer. This definition applies to supply by Mode 1. One can also measure supplies by Mode 2 on the same nationality basis. Using the nationality definitions, one can now add the supply by the companies which are owned by nationals of a country to other countries by means of the two modes. The sum of supplies by companies owned by residents of a country by means of Mode 1 and Mode 2 gives the total supply to foreign countries by its companies. This definition designates the nationality of all production in the world economy according to the nationality of the firm producing it and then distinguishes between that part of the output of the country i's firms in some industry which is produced at home and that which is produced abroad. It does not involve any double counting. Again,

this aggregation has the necessary property that the "exports" of one country are equal to the "imports" of the other country and world "exports" equal world "imports".

With these definitions, a number of other measures are also possible. For example, one might measure net exports in the sense of the net supply by both modes to markets in other countries, that is $\left(X_i - M_i\right) = \left(X_i^1 + X_i^2\right) - \left(M_i^1 + M_i^2\right)$. This may be a better measure of national comparative advantage than the traditional measures of net exports, which is equivalent to the supply by Mode 1 alone (and with no adjustment for the use of imports in export production or the nationality of firms). The following sections consider the use of these concepts for the analysis of market shares and the interpenetration of national markets.

3 Some New Concepts

The standard measure of import penetration for an industry (i), in one country is

$$P_i = M_i^1 / S_i \tag{3}$$

where S_i = total domestic sales. When we recognise the existence of two modes of cross-border supply, this measure should be modified to

$$P_i = \left(M_i^1 + M_i^2\right) / S_i \tag{4}$$

For the analysis of structural adjustments in markets in which foreign direct investment has been significant, this may be preferable to the traditional measure. One can trace the penetration of a market which is due to an increase in imports and that which is due to an increase in international production in the importing country. The obvious basis of aggregation here is the value added content in production by both modes, or possibly the labour content.

This measure of import penetration concentrates on "imports". But in many industries, trade in both goods and the outputs of foreign direct investing enterprises is two-way. We need to incorporate two-way "exports" and "imports" into our analysis. That is, the analyses of markets needs to recognise both the two modes of supply and the two-way trade in each mode. In other words, we need a set of concepts which are appropriate to markets which reflect the complex patterns of supply in an age when markets have become global.

At the level of a commodity group or "industry", the international production of goods between two countries, like the direct trade in goods as commonly measured, is two-way. Consequently, the total supply of goods between two countries is two-way. Hitherto the conception and measurement of intra-industry trade has been confined solely to direct exports and imports of goods. Using the notion of two modes of supply, one can examine and measure the intra-industry international production between two countries in precisely the same way as one examines and measures intra-industry trade. One can also sum the two sources of supply to a particular national market and the flows in the reverse direction. Such two-way flows might be called *intra-industry supply* or *extended intra-industry trade*.

This concept of extended intra-industry trade is closely related to several other areas of recent research. One is *intra-industry investment*. (For early discussions of this phenomenon, see Grubel (1979), Dunning (1981), and Dunning and Norman (1986)). What the concept of international production does is to shift the focus to the output of foreign investors, rather than the foreign investment itself. From the standpoint of evaluating adjustment to globalisation and the competitiveness of markets and other market-related features, intra-industry production is clearly more useful than intra-industry investment.[3]

The logical starting point of the analysis of these phenomena is to examine the supply to markets by both modes and the flows in the reverse direction. Extended intra-industry trade provides a general measure of the interpenetration of national markets. Such features as intra-industry merchandise goods trade, intra-industry investment and intra-firm trade are an integral part of the complex patterns of supply in modern global markets.

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[3] In principle, this concept of extended intra-industry trade, like the standard concept, can also be applied to trade in services as well as goods. Indeed, it is particularly important in the analysis of trade in services. Since the conclusion of the General Agreement on Trade in Services (GATS), it has been recognised that the cross-border delivery of services can be done by the establishment of foreign affiliates in the country in which the service is delivered, the so-called "commercial presence" mode of supply. The four modes of supply recognised in GATS are a further breakdown of the two modes listed above which is useful to analyse the particular characteristics of production and trade of services. Thus, the concept of extended intra-industry trade incorporates the explicit recognition in the analysis of service markets that they may be supplied by foreign producers producing in the country of supply or the country of destination. Furthermore, in this area, supply by the mode of international production is called "trade" in services.

Extended intra-industry trade can be measured in precisely the same way as traditional intra-industry trade. For example, one can use the Grubel-Lloyd measure (adjusted or unadjusted) (see Grubel-Lloyd 1975) or any other measure of the extent of this trade. All that is required is the redefinition of exports and imports to include both modes of supply to foreign markets.

There are two choices. One can consider intra-industry trade by Mode 1 and Mode 2 separately. Intra-industry trade by Mode 1 is the conventional type of intra-industry trade. Intra-industry trade by Mode 2 is the parallel two-way flows of international production. The measurement of these flows and the indices is straightforward. The Grubel-Lloyd indices for both modes separately are

$$A_i^j = \left\{ \left(X_i^j + M_i^j \right) - | X_i^j - M_i^j | \right\} / \left(X_i^j + M_i^j \right) \qquad j = 1 \text{ or } 2 \tag{5}$$

For $j = 1$, this gives the standard Grubel-Lloyd index of intra-industry merchandise trade. For $j = 2$, this gives the Grubel-Lloyd index of intra-industry international production. Summing across industries, one obtains a Grubel-Lloyd index of intra-industry specialisation for international production in the economy. It shows the proportion of the total international production flows in both directions which is intra-industry.

The second alternative is to aggregate trade flows by both modes and measure extended intra-industry trade as:

$$\begin{aligned} EIIT_i &= \left(X_i + M_i \right) - \left| X_i - M_i \right| \\ &= \left(\sum_{j=1,2} X_i^j + \sum_{j=1,2} M_i^j \right) - \left| \sum_{j=1,2} X_i^j - \sum_{j=1,2} M_i^j \right| \end{aligned} \tag{6}$$

The Grubel-Lloyd measure of intra-industry "trade" in the industry is

$$A_i = \left\{ \left(X_i + M_i \right) - \left| X_i - M_i \right| \right\} / \left(X_i + M_i \right) \tag{7}$$

This index may measure the extent of extended intra-industry trade in bilateral flows or in the total trade of a country, depending on the definition of "exports" and "imports". Clearly by summing across industries, an index of the economy-wide level of extended intra-industry trade can be generated. Like the Grubel-Lloyd index for goods trade alone, this is a

weighted average of the extended intra-industry trade of the individual industries and it lies in the closed interval [0,1].

The two modes of supply we are focusing on may have quite different implications in terms of their derived demand for labour and capital across countries. Thus, it would be useful to separate that component in the index which in effect reflects two-way trade and that part which reflects 'two-way production'. This can easily be done by a decomposition. Given the definitions above, extended intra-industry "trade" in an industry can be decomposed into three components:

      1.   Two-way exchange of international trade in goods (Mode1)

      2.   Two-way exchange of international production (Mode2)

      3.   Two-way exchange of international trade for international production (Mode1 and 2)

Algebraically, the decomposition of the term in Equation (5) is given by

$$\left(\sum_{j=1,2} X_i^j + \sum_{j=1,2} M_i^j \right) - \left| \sum_{j=1,2} X_i^j - \sum_{j=1,2} M_i^j \right| = 2\min\left(\sum X_i, \sum M_i \right)$$

$$= \sum_{j=1,2} 2\min\left(X_i^j, M_i^j \right) + 2\min\left(X_i^{'}, M_i^{'} \right) \qquad (8)$$

where $X_i^{'} = X_i - \sum_{j=1,2} \min\left(X_i^j, M_i^j \right)$ and $M_i^{'} = M_i - \sum_{j=1,2} \min\left(X_i^j, M_i^j \right)$. Hence, the index is an exactly decomposable index.

The three terms in Equation (8) are the three components of extended intra-industry trade. Essentially, this approach looks at international trade in goods and international production first and measures the overlap of exports and imports in these. It then measures the overlap in total exports and imports which is not due to overlap within the two modes. The first term is clearly standard intra-industry trade. The second term is the analogous flows for international production by multinational corporations. Finally the third term is the mixture of the flows for the two modes, one flow in one direction and the other flow in the reverse direction; for example, a parent company might establish a foreign affiliate and then import the output of that affiliate to be used as an intermediate input in its home production.

This decomposition offers the potential for a much fuller picture of two-way flows. Thus, extended intra-industry trade pulls together a number of strands of analysis of intra-industry trade in goods, services and factors.

4 Empirical Issues

Extended intra-industry trade and its decomposition therefore offers a potentially powerful tool for disentangling two-way flows of trade and international production and for gaining greater insight into the relationship between the two.

Clearly the data requirements for constructing the extended intra-industry trade index are more demanding than those for a standard intra-industry trade index. We still of course need data for the latter as an input. In addition, however, we require data on affiliate production and therein lies the key difficulty. Affiliate production is not as readily nor as comprehensively available as trade data, nor can it be obtained on a multilateral basis at suitable levels of country and industry disaggregation. It can for some countries at least be obtained however on a bilateral basis. The most comprehensive data available are for the US (US Bureau of Economic Analysis). Not only does this report information on US overseas affiliate production, it also reports data on overseas affiliate production in the US. This is collected on a consistent basis and disaggregated by country and industry. Since the US is the world's largest source of and host to FDI, it means that it is an especially good case to take from the standpoint of applying this new measure.

In the next section we report the results of calculating extended bilateral intra-industry trade and its components for the US. Before doing so, however, we should mention one further complication for bilateral indices, namely third country effects. We are applying our new measure in a bilateral context to gain insight into mutual interpenetration of markets. The complication is that production of foreign affiliates of country A located in country B may export to country C rather than selling their output locally in country B. In principle these flows should be excluded, in practice they cannot be. It is highly unlikely that this results in a substantial bias to affiliate production in the US, given the size of that market and the fact that most overseas affiliates locate there to penetrate that market alone. As a high-wage country, the US is not a major export platform for multinational companies of other countries. This bias is potentially more relevant to the output of US affiliates overseas where, for example, a US affiliate in the Netherlands could be established to serve the broader European market.

5   Application to US Bilateral Intra-Industry Supply

Data on the activities of US multinational corporations were obtained from the US Bureau of Economic Analysis (BEA). This provided data (for 1989-94) on sales of affiliates of US firms in alternative national markets and on sales of foreign affiliates in the US market. We consider bilateral supply between the US and five of its major industrial trading partners: Canada, Germany, France, UK and Netherlands. For each country (host market for US FDI or origin for inward US FDI) under consideration **,** the disclosed sales figures for non-service sector industries (International Standard Industry Classification) were matched to the US merchandise trade data[4.] , classified according to the 1987 SIC.[5] The resulting 'industries' correspond therefore to between the two and three digit level of the SIC; somewhat, but not excessively, more aggregated than the level used in conventional intra-industry trade analysis. The sample size is considerably constrained by non-disclosure where bilateral annual data is concerned. In order to restrict the loss of industry observations, averages were taken for two periods, namely 1989-91 and 1992-94.

Initially, the Grubel-Lloyd measure (eq. (5)) of intra-industry exchanges were calculated separately for trade and international production. These measures are reported in summary fashion in Table 1, for US bilateral exchanges with the five industrial trading partners. The specific industries and the number of industries covered in each bilateral exchange vary, and comparisons across countries need to be undertaken with caution. The number of industry observations for each period ranges from 12 to 21. For the share of armslength (Mode 1) intra-industry trade in gross trade, there are, rather surprisingly, low values in the case of Canada and France in the period 1989-91. The indices for the other countries are more in line with values from earlier studies with more extensive industry coverage; the indices ranging from 0.50 to 0.74. For intra-industry production (Mode 2), the values are in the range 0.35-0.65 over the two periods. This shows that substantial intra-industry exchange of supplies is a feature of international production, just as it is of traditional intra-industry trade. Interestingly the highest values for the shares of two-way exchange via Mode 2 are for the two countries (Germany and UK) for which the GL indices for Mode 1

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[4]   Obtained from the NBER on disk with Feenstra (1996,1997).

[5]   At the bilateral level one is forced to aggregate statistics of trade which are based on the country of production with statistics of international production which are based on the nationality of the company. This gives a hybrid measure of "extended trade".

exchange are also highest. Although the country coverage is small, this is in line with a complementarity thesis.

Table 1: Bilateral Intra-Industry Indices for Trade and International Production Separately(1)

	1989-91 Average[2]					
With	**Trade**	(paired)[4]	**Foreign Production**	(paired)[4]	**No. of observations**	(paired)[(4)]
Canada	0.00	(0.00)	0.35	(0.42)	14	(11)
UK	0.60	(0.63)	0.58	(0.56)	21	(18)
Germany	0.74	(0.73)	0.61	(0.64)	12	(11)
France	0.00	(0.00)	0.46	(0.44)	12	(11)
Netherlands	0.50	(0.53)	0.42	(0.41)	13	(11)
	1992-94 Average					
With	**Trade**	(paired)[4]	**Foreign Production**	(paired)[4]	**No. of observations**	(paired)[(4)]
Canada	0.37	(0.40)	0.45	(0.49)	13	(11)
UK	0.66	(0.66)	0.58	(0.57)	19	(18)
Germany	0.67	(0.72)	0.64	(0.70)	15	(11)
France	0.50	(0.46)	0.44	(0.46)	13	(11)
Netherlands	0.44	(0.49)	0.48	(0.48)	15	(11)

1. Grubel-Lloyd index.
2. Arithmetic average.
3. Sales by relevant foreign affiliates.
4. Industries for which measures available in both periods.

In Table 1 we also identify averages for both paired (between periods) and unpaired industry observations. Thus for the eleven common industries in the two periods for US-Canada cross supply, the Grubel-Lloyd index for trade rises from 0.00 to 0.40 and for production from 0.42 to 0.49. Although the paired indices rise or fall for particular countries in the case of two-way trade, the paired indices for two-way production consistently increase. This is indicative at least of the growing importance of two-way exchange by this mode of supply.

Table 2:   BILATERAL INTRA-INDUSTRY INDICES FOR EXTENDED TRADE[1] [2]

1989-91			
With	**Average** [3]	(paired)[4]	**Range** [3]
Canada	0.31	(0.39)	0.00 - 0.97
UK	0.70	(0.71)	0.17 - 0.99
Germany	0.66	(0.69)	0.10 - 0.98
France	0.51	(0.49)	0.11 - 0.95
Netherlands	0.52	(0.55)	0.18 - 0.96
1992-94			
	Average [3]		**Range** [3]
Canada	0.52	(0.58)	0.07 - 0.92
UK	0.70	(0.69)	0.14 - 0.98
Germany	0.66	(0.71)	0.16 - 0.95
France	0.51	(0.53)	0.12 - 0.95
Netherlands	0.59	(0.57)	0.18 - 1.00

1.   Extended intra-industry exchanges by means of armslength trade and sales by foreign affiliates

2.   Grubel-Lloyd index.

3.   For same number of observations reported on in Table 1.

4.   For same number of observations common to both periods as identified in Table 2.

If we cease to treat the two modes of intra-industry supply separately, we can estimate the Grubel-Lloyd index for extended intra-industry trade as described in equation (7). We do this for the same data set summarised in Table 1. The results of this estimation exercise are reported in summary fashion in Table 2. Crude averages for each period (and paired observations) are reported as well as the ranges of values of the index across industrial sectors. It is clear from the averages that, at this particular level of aggregation, intra-industry supply is important; with intra-industry supply accounting on average for at least 50 per cent of total supply for all countries in the second period, and all but Canada in the first period. There is, however, considerable variation across industrial sectors. The lower values in the industry range are consistently less than 0.20, and the upper values consistently greater than 0.90.

The potential importance of cross hauling of supply by both mode 1 or 2, and of distinguishing between intra-industry and extended intra-industry trade indices is forcibly illustrated by the difference in these two indices (in the first column of Tables 1 and 2). In most observations the proportion of intra-industry extended trade is higher than the proportion of intra-industry trade as conventionally measured for direct exports and imports alone.

Table 3: Decomposition of US Bilateral Intra-Industry Supply

1989-91 averages				
	TOTAL[(1)]	COMPONENTS[(2)]		
With		Trade	Foreign Production	Mixed Trade-Production
Canada	0.31	0.00	0.22	0.09
UK	0.70	0.14	0.44	0.11
Germany	0.66	0.17	0.46	0.02
France	0.51	0.00	0.38	0.13
Netherlands	0.52	0.18	0.29	0.06
1992-94 averages				
	TOTAL[(1)]	COMPONENTS[(2)]		
With		Trade	Foreign Production	Mixed Trade-Production
Canada	0.52	0.17	0.24	0.11
UK	0.70	0.16	0.44	0.11
Germany	0.66	0.18	0.48	0.01
France	0.51	0.11	0.32	0.08
Netherlands	0.59	0.18	0.30	0.11

1.   Indices of intra-industry supply given in Table 2 for maximum number of observation available for each time period.

2.   Decomposition of total index given by equation (7) in text.

In Table 3 we explore the relative importance (on average) of mode 1 and 2 forms of intra-industry supply, using the decomposition in equation (7). Each component is now expressed as a proportion of the total supply (ie by both mode 1 and mode 2). Presented in this form, it is evident that international production is the dominant mode of intra-industry

supply for US exchanges with these industrial countries; the international production component being well in excess of half of the total index in all but one case (Canada in 1992-94), when international production is still the dominant mode of intra-industry supply). Interestingly this pattern of dominance is the same for both US-Canada exchanges and for US exchanges with the more distant European countries. It should be emphasised that lower values for intra-industry supply for US-Canada than for US-UK exchange imply higher values of inter-industry supply for the former than the latter country pairing. Supply of foreign markets by either mode 1 or mode 2 can be important in the case of both intra- and inter-industry specialisation.

The residual component of mixed trade and international production in Table 3 is small relative to the other two components. The mixing of supply in one direction by mode 1 only with mode 2 only in the other direction is 0.13 for all observations. But it is not negligible. As shown above, we can formally regard "exports" and "imports" and the two-way exchange of "exports" and "imports" as the aggregation of the two modes of supply. Because of the mixed component, the index of extended intra-industry supply has the property that it must exceed the average of the indices of intra-industry supply by mode 1 and mode 2 (see Equation (8) and the component columns of Table 3). This is true of all observations.

In Table 4 we provide industry results for US-UK intra-industry supply for the 1992-4 period. The general pattern of the results described above still holds when we examine these disaggregated results. Two-way foreign production (Mode 2) remains the dominant component of intra-industry supply; being the largest component of the total index for 16 of the 19 industries covered by the empirical analysis. There are some exceptions; 'other transport equipment' where armslength trade and 'non-ferrous metals' dominates and 'mining' where mixing of modes dominates. Clearly further empirical work is required to test whether aggregation effects and trade in components is affecting the results for specific sectors. But the consistency and pattern of the results across industrial sectors gives some encouragement that the extended intra-industry trade concept offers important insights. One would anticipate tradability issues, transport costs and trade policy barriers to produce the type of cross industry variations in the levels and components of intra-industry supply that are shown in Table 4; with foreign production being the particular dominant mode of two-

Table 4: Sector Breakdown of Total Intra-Industry Supply and Its Components for US-UK Exchanges: 1992-4

SECTOR	TOTAL	COMPONENTS		
		Trade	Foreign Production	Mixed Trade-Production
Agriculture, forestry and fisheries	0.63	0.13	0.36	0.13
Audio, video and comm.	0.91	0.27	0.36	0.28
Construction	0.90	0.00	0.90	0.00
Electrical machinery	0.80	0.32	0.44	0.04
Electronic components	0.63	0.23	0.39	0.00
Fabricated metal products	0.95	0.14	0.78	0.04
Ferrous metal industries	0.60	0.15	0.44	0.00
Instruments and related prods	0.90	0.15	0.70	0.06
Lumber and furniture	0.70	0.12	0.30	0.28
Mining and other extraction	0.14	0.00	0.00	0.13
Misc. plastic products	0.80	0.17	0.63	0.00
Motor vehicles and equipment	0.21	0.05	0.11	0.05
Non-ferrous metal industries	0.96	0.11	0.17	0.68
Other transport equipment	0.85	0.57	0.05	0.23
Paper and allied products	0.98	0.09	0.82	0.07
Printing and publishing	0.65	0.11	0.54	0.00
Rubber products	0.53	0.16	0.34	0.03
Stone, clay and glass products	0.42	0.06	0.36	0.00
Textile products & apparel	0.75	0.18	0.57	0.00
Average	0.70	0.16	0.44	0.11

way supply in construction, fabricated metal products and paper and allied products for example, and arms-length trade more important where sectors are not subject to high natural trade barriers (eg electrical products) or to very high fixed costs of production (eg other transport equipment). Similarly the mixing of trade and production modes is likely to be fashioned by natural resource endowments, and is likely to be important therefore in mining and non-ferrous metal industries.

Table 5: Decomposition of US Bilateral Intra-Industry Supply: Selected Industries

	TOTAL	COMPONENTS		
		Trade	Foreign Production	Mixed Trade-Production
a) ELECTRONIC COMPONENTS				
Canada	0.53	0.42	0.11	0.00
UK	0.63	0.23	0.39	0.00
Germany	0.89	0.25	0.61	0.04
France	0.62	0.30	0.33	0.00
Netherlands	0.88	0.10	0.71	0.07
b) LUMBER & FURNITURE				
Canada	0.19	0.00	0.19	0.00
UK	0.70	0.12	0.30	0.28
Germany	0.87	0.19	0.68	0.00
France	0.95	0.31	0.50	0.14
Netherlands	0.36	0.25	0.11	0.00
c) PLASTIC PRODUCTS				
Canada	0.91	0.21	0.35	0.35
UK	0.80	0.17	0.63	0.00
Germany	0.95	0.18	0.78	0.00
France	0.59	0.11	0.42	0.06
Netherlands	0.18	0.03	0.15	0.00
d) TEXTILES & APPAREL				
Canada	0.92	0.31	0.39	0.22
UK	0.75	0.18	0.57	0.00
Germany	0.94	0.25	0.64	0.06
France	0.91	0.08	0.75	0.08
Netherlands	0.94	0.23	0.58	0.13

1992-94 Averages

Finally in Table 5 we report on detailed results for four specific industries for which results were available for US exchanges with all five countries. Again the pattern of results across

bilateral exchanges for each industry shows some consistency and is in line with expectations. Foreign production is generally the dominant mode of intra-industry supply in these industries, armslength trade is for instance of greater relative importance where tradability is greater (eg electronic components and textiles and apparel). There are**,** however**,** likely country-specific effects (distance between trading patterns, natural resources endowments and policy incentives) that mean that the level and composition of intra-industry supply does vary for the same industry in these US bilateral exchanges. Of course it has to be recognised that there may also be some third country effects that distort the measures, with sales for instance from US production in one EU country going to another EU country. Again this is more likely to occur in industries whose products are more tradeable within the EU.

6 Summary and Conclusion

It is well known that there is a relationship between (armslength) international trade and (multinationals') international production. Neo-classical trade theory sets out conditions under which they will be substitutes; modern trade theory elaborates on the conditions under which they will be complements. Some empirical analysis does test for substitutability/complementarity. However, the absence of a common metric means that this has to be an indirect test.

In this paper we set out the rationale for a family of new measures which make for a more direct 'like for like' comparison of armslength trade and international production. The measures explicitly recognise that two-way exchanges of goods, two-way exchanges of international production and two-way exchanges of one for the other all simultaneously occur and offer a way of disentangling them. The data requirements of implementing these measures are exacting. Nonetheless we do so by focusing on US bilateral exchanges of trade and production. Moreover we do so on both a cross-country and cross-industry basis.

The results of calculating our new measure of extended intra-industry trade and its components are very revealing. In particular they demonstrate just how important two-way international production is relative to two-way trade. It accounts for most of the two-way extended trade. Given the growth of FDI relative to armslength trade over the last decade, many analysts and policy makes may have had suspicions that this was so; as far as we are aware this is the first time it has been demonstrated in this way. Moreover, when the mode of supply of foreign markets by international production is recognised, these new measures

show that levels of two-way interpenetration of markets is even higher than the levels of two way (intra-industry) direct merchandise trade.

There are several directions for future work. First, it would be useful to replicate the analysis for a wider range of countries and industries. Secondly, the aggregation of supplies from one country to another by both modes yields a new definition of extended supply across national borders. Tests of comparative advantage among countries could be conducted in terms of this extended concept of supply. Thirdly, this aggregation does suggest that in thinking about adjustment issues associated with globalisation, it is a mistake to focus only on arms-length trade.

References

Agmon, T. (1979), "Direct investment and intra-industry trade: substitutes or complements?" in Giersch, H. (ed.) *On the Economics of Intra-Industry Trade*, JCB Mohr, Tübingen.

Brainard,S. Lad (1997), "An empirical assessment of the proximity-concentration trade-off between multinational sales and trade", *American Economic Review*, vol. 87, pp. 520-44.

Cantwell, J. (1994), "The relationship between international trade and international production", in Greenaway, D. and Winters, L.A. (eds), *Surveys in International Trade*, Oxford, Blackwell.

Carr, D.L. Markusen, J.R. and Maskus, K. (1998), "Testing the knowledge-capital model of the multinational enterprise", paper presented to The First Annual Workshop on Empirical Research on International Trade and Investment, Fredensborg, Denmark, 19-21 June, 1998.

Caves, R.E. (1996), *Multinational Enterprise and Economic Analysis*, Cambridge, Cambridge University Press.

Dunning, J. (1981), "A note on intra-industry foreign direct investment", *Banca Nazionale del Lavoro Quarterly Review*, no. 139, pp. 427-37.

Dunning, J.H. and Norman, G. (1986), "Intra-industry investment" in H.P. Gray (ed.), *Research in International Business and Finance*, vol. 5, JAI Press, Greenwich, Conn.

Ekholm, K. (1997), "Factor endowments and the pattern of affiliate production by multinational enterprises", CREDIT Paper 97/19, University of Nottingham.

Ethier, W.J. (1994), "Multinational Firms in the Theory of International Trade", in Bacha, E. (ed.), *Economics in a Changing World*, Macmillan, London.

Ethier, W. J. (1996), "Theories about Trade Liberalisation and Migration: Substitutes or Complements" in Lloyd, P. J. and Williams, L. (eds), *International Trade and Migration in the APEC Region*, Oxford, Oxford University Press.

Greenaway, D., Hine, R.C. and Milner, C.R. (1995), "Vertical and horizontal intra-industry trade", *Economic Journal*, vol. 95, pp 1505–14.

Grubel, H. G. (1979), "Towards a Theory of Two-way Trade in Capital Assets", in H. Giersch (ed.), *On the Economics of Intra-industry Trade*, J.C.B. Mohr, Tübingen,

Grubel, H.G. and Lloyd, P.J. (1995), *Intra-industry trade*, Macmillan, London.

Julius, D. (1990), *Global Companies and Public Policy*, RIIA, London.

Feenstra, R.C. (1996), "US Imports, 1972-94: Data and Concordances", NBER Working Paper 5515.

Feenstra, R.C. (1997), "US Exports, 1972-94: with State Exports and Other US Data", NBER Working Paper 5990.

Markusen, J.R. (1995), "The boundaries of multinational enterprises and the theory of international trade", *Journal of Economic Perspectives*, vol. 9, pp. 169-89.

Markusen, J.R. (1998), "Multinational firms, location and trade", *The World Economy*, vol. 21, pp 733-56.

Markusen, J.R., Venables, A.J., Konan, D.R. and Zhang, K.H. (1996), "A Unified Theory of Horizontal Direct Investment, Vertical Direct Investment and the Pattern of Trade in Goods and Services", NBER Working Paper 5696.

Petri, P. (1997), "Foreign direct investment in a computable general equilibrium framework", paper presented to the Conference on Making APEC Work: Economic Challenges and Policy Alternatives, Keio University, March 13-14 197.

United Nations Conference on Trade and Development (UNCTAD) (1995), *World Investment Report: Transnational Corporations and Competitiveness*, UNCTAD, New York.