The Bias of Intrafirm Trade in the Linder Trade Model

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Linder’s thesis (1961) explaining trade among industrialized partners does not account for trade within the multinational firm. By law, intrafirm trade is counted in aggregate trade statistics used to test Linder’s thesis. The volume and geography of that trade introduce a bias into those tests. This article reviews Linder in terms of intrafirm trade, briefly documenting the influence and geography of intrafirm trade. It goes on to demonstrate that intrafirm trade should be treated as an endogenous variable, and tests an amended Linder model of trade. Results from estimations of bilateral flows in four manufacturing sectors strongly support Linder’s thesis. Key Words: intrafirm trade, Linder Hypothesis.

The Linder Hypothesis (1961) is a keystone of analyses of international trade. Economists typically employ it to analyze intraindustry trade (Hoftyzer 1984; Farrell 1991; Doroodian 1992; Chow, Kellman, and Shachmurove 1999). Geographers use it to analyze the patterns and composition of all trade (Hanink 1988). The Linder thesis is important because of the way in which it explains the persistent flow of similar industrial products among rich countries, which constitutes the bulk of international trade. The thesis provides two complementary explanations for this geography of international trade: similarities in the demand structures of trading partners and the distance between them.

These explanations would seem appropriate given the dominant geographical patterns of global trade. Flows among rich countries accounted for fully 76 percent of total world trade in 1999, up from 71 percent in 1970 and 63 percent in 1981 (Grimwade 2000). Strong intraregional linkages are evident in these flows. Trade among Western European countries comprised more than 75 percent of their total trade (Jestin and Gampel 2000). By 1998, trade among Japan and its rich Asian neighbors measured almost 80 percent of partners’ total trade volume (Jestin and Gampel 2000). Trade patterns for the U.S. have both a strong regional character and solid ties to rich countries in other regions. In 1998, the leading U.S. export markets included Canada (U.S. $156 billion), Mexico (79 billion), Japan (58 billion), the U.K. (35 billion), and Germany (27 billion). As for U.S. imports at that time, the largest flows included those from Canada ($175 billion), Japan ($122 billion), Mexico ($95 billion), China ($71 billion), and Germany ($50 billion). Linder’s thesis has become an important framework for analyzing these flows (Chow, Kellman, and Shachmurove 1999).

This article argues that there are dimensional and geographical biases in empirical tests of Linder’s thesis. By law, intrafirm trade must be reported as arms-length transactions and so is included in aggregate measures of trade volume (Hines 1996). This article asserts that the presence of intrafirm trade volume in aggregate import–export data, and the persistent geography of that intrafirm trade, prejudices the results of those tests. This is because intrafirm trade, which stems from the efficient global arrangement of production rather than from demand similarities, is not likely to mirror consumer-driven trade.

The article begins by showing that intrafirm trade is inconsistent with Linder’s notion of exporters’ imperfect knowledge of foreign demand preferences, and so must be removed from partners’ trade data. It then goes on to argue that intrafirm trade must be included in any test of Linder’s thesis as an independent variable insofar as such trade informs local affiliate producers about the production structure, which Linder argues arises to meet demand structures in foreign markets. An amended Linder model, with intrafirm trade removed from the dependent variable and included as an explanatory variable, is then estimated. Discussion and conclusions close the article.

Linder’s Thesis: Review and Comment

Linder’s (1961) thesis states that the geography of trade in manufactures is based on the similarity of demand structures among countries. Briefly, Linder argues that countries having sim-
ilar factor endowments and, consequently, similar income levels would have similar demand structures for manufactures. He maintains that such countries would produce a common set of manufactures having similar attributes whose differences stem from local demand preferences and would then trade heavily in those goods because of this product differentiation, but not reach full trade potential due to trade-braking forces, of which distance is the most important. Increasing distance reduces this trade, primarily by diminishing the knowledge entrepreneurs have about foreign market opportunities and demand preferences.

The process underpinning this trade begins with production to meet domestic demand. Domestic demand preferences determine product characteristics, because scale economies make producing all varieties impractical and thus skew domestic production in favor of domestic tastes. Scale economies compound and surplus production accrues. Surplus production gets exported. Thus, export goods are local varieties of particular goods. Export markets for local varieties are those in which there is a demand in some amount for these types of goods. This demand in foreign markets implies that producers in those markets already manufacture their own local varieties of these goods. To know which foreign markets have demand and local production of similar goods, exporters must be near them. Therefore, countries geographically close and with similar demand conditions will end up producing a similar range of goods, differentiated by domestic demand preferences, and will trade them with each other. This exchange of similar goods is known as intraindustry trade.

Several features of this argument hold serious complications for empirical research. First, as a strictly demand-oriented thesis, Linder's has not sufficiently theorized all of intraindustry trade, much of which is trade within multinational firms (Zeile 1997; Mataloni 1998). Intrafirm trade is embedded in reported trade statistics because, by law, firms must report intrafirm trade values as if they were arms-length transactions (Hines 1996). Trade within multinational firms involves such a different scale of analysis that a single theory of trade between countries and of trade within multinational corporations is unlikely (McConnell 1986; Hanink 1989).

Second, Linder leaves scant room for analysis in which multinational firms are consumers. The emphasis upon differences in domestic and foreign demand preferences precludes the notion of globally linked production facilities supplying one another with goods having necessarily known characteristics. Thus, Linder's stipulation about imperfect knowledge of foreign demand preferences contradicts trade within the multinational firm.

Third, Linder is not sufficiently theorized in terms of intermediate products, which constitute a large share of intraindustry trade and an even larger share of trade within multinational firms (Zeile 1997; Mataloni 1998). These are clearly not Linder-type goods: they are of specified designs, since they must be assembled into larger, final products at some point. Thus, they must be identical no matter the country of origin. There can be no differentiation, geographic or otherwise, across intermediate parts (Handfield 1994; Mihaly 1998; Drickhamer 2000).

For empirical research to accurately assess Linder's thesis, the value of trade within the multinational firm must be removed from aggregate intraindustry trade data. If unadjusted, the measurement of intraindustry trade introduces both a dimensional and directional bias. The fact that it has not been adjusted may help to explain why results from tests of Linder's thesis have been mixed (Sailors, Qureshi, and Cross 1973; Hoftyzer 1975; Greutack and McHugh 1977; Kohlhagen 1977; Pagoulatos and Sorenson 1979; Loertscher and Wolter 1980; Qureshi, French, and Sailors 1980; Töh 1982; Havrylyshyn and Givan 1983; Michael 1983; Hoftyzer 1984; Balassa 1986; Hanink 1989, 1990; Bergstrand 1990; Farrell 1991; Doroodian 1992; Chow, Kellman, and Shachmurove 1999). The next section describes the magnitude and geographical biases in these tests stemming from the use of unadjusted measures of trade.

Bias in the Intraindustry Trade Measure

There are four common measures of intraindustry trade used to test Linder thesis: the logit
of trade share, the Grubel-Lloyd Index, the per capita volume of intraindustry trade, and intraindustry trade propensity (Fortune 1979; Bergstrand 1990; Chow, Kellman, and Shachmurove 1999). All four measures suffer from both a magnitude bias and a geographical bias. In addition, the propensity measure is conceptually flawed as well as biased.

The magnitude bias in all four measures stems from the volume of intrafirm trade that is included in aggregate tallies of intraindustry trade. Intrafirm trade is the import-export flow of products through the network of home-country parent firms and their foreign affiliates, in both hierarchical and lateral directions. These flows are not Linder-type: they are a function of the efficient spatial arrangement of global production, not of consumer demand for differentiated products (Zeile 1997; Mataloni 1998).

Data on export-import activities of U.S. multinational firms (U.S. MNFs) demonstrate the significance of this bias. The intrafirm trade of U.S. MNFs totaled $728 billion in 1996 and accounted for 65 percent of all U.S. exports and 40 percent of all U.S. imports (Mataloni 1998). This bias is most pronounced in the intraindustry trade of manufactures. The share of intrafirm imports from U.S. MNFs’ majority-owned foreign affiliates (MOFAs) accounted for by manufacturing affiliates has increased markedly, from less than 50 percent in 1977 to more than 80 percent in 1994. The share of intrafirm exports to MOFAs accounted for by manufacturing affiliates has declined somewhat since the mid-1980s, when it exceeded 70 percent. Naturally enough, trade flows between foreign affiliates and U.S. MNFs reflect the sectoral and geographical distributions of their production arrangements.

In sectoral terms, much of the intrafirm trade with manufacturing affiliates is in motor vehicle and parts. There are several reasons for this. Two of the world’s four biggest multinational firms are U.S. automakers (Ford and GM). Together, they have foreign assets totaling near $200 billion, foreign sales of more than $300 billion, and 1999 foreign production over $150 billion (Drickhamer 2000). The inclusion of figures for the merged DaimlerChrysler automaker raises these totals, on average, another $100 billion. The international network of intrafirm trade these companies command is driven by programs of global sourcing, plat-
some of the largest source countries for U.S. imports.

The nature of this geographical bias is such that the explanatory power of analyses derived from Linder is influenced by intrafirm trade flows that are reported in aggregate trade figures. Together with the magnitude bias, this geographical bias confounds attempts to accurately assess Linder’s thesis. Thus, analyses using unadjusted trade data are prejudiced by the large volume of intrafirm trade that is included in reported values of intraindustry trade. Resolving both the magnitude and geographical biases requires only that the volume of intrafirm trade be removed from aggregate trade volume data.

To simply discard intrafirm trade would be wrong, for two reasons. First, U.S. parent firms need have only a 50 percent stake in a foreign firm for it to be classified as a MOFA. Thus, some production in foreign markets may not be entirely dedicated to the parent firm. This is especially true of automotive parts production, in which many foreign affiliates also produce after-market products for export (Milligan 2000). More importantly, insofar as this intrafirm trade informs those foreign producers about their parent’s production structure, it also serves to inform them about the demand structures of the parent firm’s home country. This is also true for parent firms as producers. This makes intrafirm trade a “true” Linder variable: one that mediates the knowledge local producers have of foreign demand preferences. Thus, any test of the Linder thesis must include intrafirm trade as an explanatory variable, because it inversely expresses a measure of “imperfectness” in the knowledge producers have about foreign markets.

The propensity to trade measure, commonly measured as intraindustry trade volume per GDP or per GNP, is simply inappropriate. Measured this way, the variable actually measures the propensity to produce for trade, rather than the propensity to trade similar goods with any particular partner.

Measurement Bias: Misspecifications

Other measurement issues confound tests of the Linder Hypothesis. Discussed extensively elsewhere (Hoftyzer 1984; Hanink 1988; Dorrodian 1992), these include: procedural errors in treating no trade values as missing data rather than as zero trade; autocorrelation problems when both an income-similarity measure and a distance measure are included in the estimated model; unexplained simplification of the estimated model by excluding distance; and failure to account for the geographical clustering and contiguity of countries with similar income/production/demand characteristics.

Methods and Model

The analysis begins with a simple Linder model that has been amended to account for intrafirm trade. Removing the volume of intrafirm trade from the trade intensity (dependent) variable is important. Insofar as intrafirm trade is primarily in products having specified characteristics as determined by the parent company, both the imperfect knowledge of foreign markets and the concomitant product differentiation between local and imported goods central to Linder’s thesis are violated without this adjustment. Including it as an explanatory variable is also important, because it inversely expresses a measure of “imperfectness” in the knowledge producers have about foreign markets.

The estimated model, then, is

\[
LNPCT = b_0 + b_1 \text{LNDIF} + b_2 \text{LNIFT} + b_3 \text{LNDIS} + e
\]

where LNPCT is the common logarithm of the per capita imports (exports) of the U.S. from (to) country i adjusted for intrafirm trade flows, LNDIF defines the domestic market similarities as the common logarithm of the absolute difference in per capita income between the U.S. and country i measured in current U.S. dollars, LNIFT is the common logarithm of total intrafirm trade imports (exports), and LNDIS is the common logarithm of the great circle distance between economic centers of the U.S. and country j.

The scale of analysis is dictated by the limits of intrafirm trade data. Such data are reported for U.S. MNFs by country of export and import only at one-digit Standard Industrial Trade Classification (SITC) manufacturing categories. Aside from exports by their U.S.-based foreign affiliates, such data for non-U.S. MNFs are not reported. Thus, bilateral flow data in the model are necessarily limited to the U.S. and its top forty trading partners and to SITCs 5 (Chemicals and Related Products), 6 (Manufactured
Goods Classified Chiefly by Material), 7 (Machinery and Transport Equipment), and 8 (Miscellaneous Manufactured Articles) (Tradeport).

Using only U.S. MNF trade data is not as restrictive as it appears: MNFs are overwhelmingly concentrated in rich countries, comprise the largest share of traders, and are responsible for the bulk of world trade (Zeile 1997; Mata- loni 1998; Lipsey 1999). The U.S., then, serves as a strong example of the overlap between intrafirm trade and Linder-type trade. While it is desirable to have intrafirm trade data for more countries’ MNFs, data are not available.

Data on total trade between the U.S. and its top forty trading partners are taken from the U.S. International Trade Association, which reports total U.S. import and export trade flows by country at the one-digit SITC level. Data on U.S. MNFs’ intrafirm trade are available from the Bureau of Economic Analysis’s 1994 benchmark survey on U.S. direct investment abroad (1999). Data on per capita income in current U.S. dollars and population are reported in the World Bank Development Tables (World Bank Group 2001).

Results and Discussion

Table 1 lists the results from estimating equation (1) for each one-digit SITC. The results indicate strong support for Linder’s thesis. All variables have the expected signs, but not all are statistically significant in each estimate, and the estimates have reasonable explanatory power. Diagnostics indicate that multicollinearity is moderate in all four estimates. Variance inflation factors, which assess increases in the standard error of the estimated coefficients due to linear relations in the data, are always near 1.0. This is understood to indicate that multicollinearity is not a serious problem (Kleinbaum, Kupper, and Muller 1988). The condition index (CI), which measures linear dependency in the data via the square root of maximum-to-minimum-eigenvalue ratio for variables in the estimation, exceeds 10 only in SITC7. This is generally an indication that multicollinearity is less than moderate (Gujarati 1995). Klein’s (1962) rule of thumb, which asserts that the r² of auxiliary equations regressing each independent variable on every other should not be larger than that for the model, is never violated. This is taken to mean that multicollinearity is not a serious problem.

The performance of the differences-in-income variable across all four estimates can be considered strong support for Linder’s thesis. Intrafirm trade does indeed act to augment Linder-type trade as expected, but is significant only in the two sectors for which global linkages are important, SITC 5 and SITC 7. Distance acts as a brake to trade to any statistically significant degree only in SITCs 5 and 6.

With regard to SITC 5, the chemical industry is one of the leading U.S. exporting sectors, generating over 10 percent of the nation’s total exports and 13 percent of all world chemicals exports. Most of the sector’s exports consist of commodity chemicals, with foreign demand levels largely a function of general economic activity in overseas markets. The significance of both intrafirm trade and distance in these results probably stems from key trends in the global chemicals industry: specialization, globalization, and consolidation. Specialization has resulted in firms divesting low-margin chemicals to concentrate on higher-margin specialty chemicals as a means of increasing profits and returns to shareholders. Globalization and con-

| SITC 5: Chemicals and Related Products; SITC 6: Manufactured Goods Classified Chiefly by Material; SITC 7: Machinery and Transport Equipment; SITC 8: Miscellaneous Manufactured Articles. |
|---|---|---|---|---|---|
| SITC | Constant | LNDIF | LNIFT | LNDIS | R² | F | n |
| 5 | 17.435 | –0.931 | 0.192 | –0.779 | 0.491 | 21.95 | 76 |
| 6 | 21.02 | –0.806 | 0.0583 | –1.217 | 0.389 | 14.65 | 75 |
| 7 | 15.965 | –1.087 | 0.236 | –0.693 | –0.295 | 4.836 | 76 |
| 8 | 13.628 | –0.897 | 0.117 | –0.292 | 0.299 | 10.64 | 77 |

* t-scores in parentheses.
solidation are evident in the mergers and acquisitions activities of firms. The value of all mergers and acquisitions exceeded $45 billion in 1999, including the $1.3 billion merger of Dow Chemical and Union Carbide. Thus, trade in chemicals and related products is clearly informed by intrafirm connections and by geographically concentrated markets for high-priced commodity chemicals, especially in Western Europe, Canada, and Japan.

With regard to SITC 6, the results reflect the broad range of products in the sector. Items in SITC 6 include those made chiefly of stone, steel, leather, rubber, cotton, synthetics, or aluminum, and so on. The volume of trade in these items is much smaller than that in other sectors for both intrafirm trade and total trade. These items are typically bulky and heavy and have lower per-unit prices (Mataloni 1998). Together, these characteristics interact to produce results in which intrafirm trade is not statistically significant and distance is. Still, the presence of Linder-type trade appears to be present in these flows.

With regard to SITC 7, intrafirm trade augments Linder's theorized flows, but distance does not seem to act as Linder suggested to a statistically significant degree. This lack of statistical significance for the distance variable may be due to the global dispersion of suppliers and markets for transportation-related and miscellaneous manufactured products. Trade in SITC 7 is dominated by the exchange of auto vehicles and parts. The results reported here probably stem from the global scatter and fragmentation of auto parts production, along with the global diffusion of markets for autos and parts (Campbell and Chase 1996; Mapleston 1996; Kasouf and Celuch 1997; Rappleye 1997; Santucci 1997; Milligan 2000). This means that autos, trucks, and parts are exchanged in huge volumes among many partners in all directions (Santucci 1997). As such, information producers’ gain from intrafirm connections yields some gains in foreign markets, while the competition from global networks of producers probably disguises the effects of distance.

SITC 8 may be the most purely “Linder” of categories, insofar as more than half of the products classified in that sector are miscellaneous consumer goods (Warner 1994). If this is so, these results suggest that approaches derived from Linder correspond with respect to demand similarities, but do not with respect to distance and intrafirm trade. However, this interpretation must be made with caution: intrafirm trade in miscellaneous consumer goods is much smaller than in other sectors, and the sector is too broadly defined to engender much confidence in large-scale declarations.

Residuals from these estimates exhibit a principal characteristic that supports both Linder’s thesis and the importance of including intrafirm trade in Linder-based trade models. In those flows that are larger than predicted, U.S. imports, with intrafirm trade removed, are more than 19 percent greater in total volume than corresponding export flows. Moreover, the countries from which these underpredicted imports originate are typically those with significant U.S. MNF presence: Canada, Germany, France, Spain, Sweden, Ireland, Singapore, Hong Kong, Korea, Taiwan, Malaysia, Thailand, and Mexico. This suggests that U.S. foreign affiliates have both satisfied their parent’s production requirements and learned the demand preferences of U.S. consumers by having done so. As such, it can be tentatively proposed that intrafirm trade aids in generating larger Linder-type trade flows, assuming that such flows are informed by the parent-affiliate relation.

Taken together, these results raise the possibility that simple Linder models may be underspecified. Gujarati (1995) favors a modified Durbin-Watson statistic to test for this specification error in cross-section models. After ordering the cases by magnitude of the omitted variable, the d-statistic is calculated as usual. The residuals from such an ordered model contain the effect of the omitted variable. Thus, positive “correlation” in the ordered residuals is a measure, not of (first-order) serial correlation, but of model specification error with respect to the omitted variable (Gujarati 1995, 463). In all cases except for SITC 7, the null hypothesis that there is no “correlation” in the ordered residuals cannot be rejected. (For SITC 7, the results are inconclusive.) These results are interpreted to mean that the simple Linder model cannot be proven to be underspecified when tested with the data in this study.

A general word of caution is also in order here. Hanink (1987) has reported that U.S. trade patterns are anomalous, so care in interpreting these results may be warranted. However, Linder (1961) makes no concession to
country characteristics that might produce atypical patterns, so such deviance would have to be considered to refute his thesis.

**Conclusion**

This article has shown that the presence of intrafirm trade in aggregate trade volume data introduces a dimensional and geographical bias into empirical analyses of the Linder thesis. Such bias can be resolved for those trading partners who report intrafirm trade. As part of this resolution, the presence of intrafirm trade should be accounted for theoretically as an explanatory agent of both total trade and intraindustry trade. When doing so with data for the U.S. and its top forty trading partners, results indicate strong support for the Linder thesis.

From here, it is important to capture intrafirm trade for a more comprehensive set of countries. However, it is more important to capture the full impact of intrafirm trade, not just the parent-affiliate flows that comprise this study. Intrafirm trade flows laterally among affiliates as well as hierarchically between affiliates and parent MNFs (Mataloni 1998; Lipsey 1999). Given this fact, intrafirm trade informs affiliates and parent MNFs (Mataloni 1998; Lipsey 1999). Such bias can be resolved for those trading partners who report intrafirm trade. As part of this resolution, the presence of intrafirm trade in aggregate trade volume data introduces a dimensional and geographical bias into empirical analyses of the Linder thesis. Such bias can be resolved for those trading partners who report intrafirm trade. As part of this resolution, the presence of intrafirm trade should be accounted for theoretically as an explanatory agent of both total trade and intraindustry trade. When doing so with data for the U.S. and its top forty trading partners, results indicate strong support for the Linder thesis.

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**Literature Cited**


