

EMPIRICAL APPROCHES TO INTERNATIONAL TRADE*

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1. Introduction

This article reviews empirical research in international trade, which until recently was the poor relation of its theoretical sibling, but has undergone a resurgence over the last twenty years. Section 2 surveys empirical analyses of “traditional trade theory” in which cross-country differences in opportunity costs of production (comparative advantage) are the basis for the international exchange of goods and factor services. Section 3 turns to empirical analyses of “new trade theory” in which consumer love of variety and increasing returns to scale account for trade in similar goods between similar countries. In both areas, empirical research has traditionally exploited relatively aggregated data on countries and industries. More recently, new insights from micro data have altered our understanding of the nature of international trade. Section 4 reviews empirical studies using more finely-detailed trade data on individual products. Section 5 discusses empirical analyses using firm and plant-level datasets. Section 6 examines empirical approaches to trade policy. With a wide territory to explore, the discussion is inevitably selective, and related fields such as foreign direct investment and the empirical economic geography literature are left for discussion elsewhere.

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2. Traditional Trade Empirics

The idea that comparative advantage provides an explanation for “inter-industry trade” (the international exchange of one set of goods for another) dates back to Ricardo (1817), who emphasized technology differences as the source of cross-country variation in opportunity costs of production. While some early empirical studies adopted a Ricardian perspective (e.g. MacDougall 1951), much of the empirical analysis of traditional trade frameworks has been concerned with the Heckscher-Ohlin (HO) model (Heckscher 1919 and Ohlin 1924). In contrast to its Ricardian counterpart, the HO model assumes that countries have identical technologies, and instead emphasizes variation in country factor endowments and industry factor intensities as the source of differences in opportunity costs of production.

The stylized version of the HO model assumes two factors of production (capital and labor), two countries (one capital-abundant), and two goods (one capital-intensive at all factor prices). In this stylized case, the model yields four sharp predictions: (a) The HO Theorem - the capital-abundant country exports the capital-intensive good; (b) The Factor Price Equalization Theorem - with diversified production, international trade equalizes factor prices; (c) The Stolper-Samuelson Theorem - with diversified production, an increase in the relative price of the labor-intensive good raises the relative and real return to labor and reduces the relative and real return to capital; (d) The Rybczynski Theorem - with diversified production, an increase in the endowment of labor leads to a more than proportionate increase in the output of the labor-intensive good and reduces output of

the capital-intensive good.

Early empirical examinations of the HO model were loosely motivated by these four theorems. In seeking to test the HO Theorem, Leontief (1953) found that U.S. exports were less capital-intensive than U.S. imports, which appeared paradoxical within the confines of the stylized HO model. The key to resolving this paradox in Leamer (1980) was in rigorously deriving the correct empirical predictions directly from the theory. Indeed, a distinguishing feature of recent empirical studies of the HO model has been the derivation of empirical specifications from general equilibrium trade theory and the explicit recognition of the complexity of the model's predictions with many goods and factors of production.

With many goods and factors of production, and in the absence of trade costs, the theorems of the HO model are considerably weaker than in the $2 \times 2 \times 2$ stylized version, and only hold as averages or correlations. We begin by examining predictions for international trade (the generalization of the HO Theorem). The many-good, many-factor version of the model does not predict the pattern of trade in individual goods, but does predict the pattern of trade in individual factor services. A country that is abundant in a factor is predicted to be a net exporter of the factor, where factor abundance is defined as an endowment exceeding the country's share of world consumption times the world factor endowment. Therefore, many empirical studies of the HO model have focused on its predictions for net trade in factor services. Following Leamer (1984)'s early and influential treatment, Bowen *et al.* (1987) were the first to observe that a full test of the model's predictions for factor service trade requires three sets of

separate data on international trade, factor input requirements and factor endowments. Early empirical results were discouraging from the point of view of the explanatory power of the theory. Bowen *et al.* (1987) found that the HO model performed no better than a coin toss in predicting the direction of a country's net trade in factor services. In response, Trefler (1993) argued that factor-augmenting technology differences could both explain patterns of trade in factor services and account for cross-country variation in factor prices. Under this hypothesis, first mooted in Leontief (1953), the HO model's predictions for factor service trade and of factor price equalization only hold once one controls for cross-country differences in the efficiency of factors of production. In subsequent work, Trefler (1995) identified two systematic departures between predicted and measured net trade in factor services: (a) "The Case of the Missing Trade" where measured factor services trade is close to zero and much smaller than predicted by the HO model; (b) "The Endowments Paradox" where rich countries are scarce in most factors and poor countries are abundant in most factors.

One strand of recent research has argued that the HO model's predictions for factor service trade are much closer to the measured values for trade between regions within countries, where the model's assumptions of identical technologies, factor price equalization and identical and homothetic preferences are more likely to be satisfied. Davis *et al.* (1997) provide evidence supporting the HO model's predictions using data for trade between Japanese regions. A second strand of research has argued that factor-augmenting technology differences are not enough to explain international trade in factor services, but that a reconciliation between theory and data

is ultimately possible. Davis and Weinstein (2001) provide evidence that international trade in factor services can be successfully explained if the HO model's assumptions are relaxed to introduce cross-country differences in technology that vary between industries ("non-neutral" technology differences), trade costs and non-factor price equalization. While predicted and measured net factor service trade have been brought into line, the model is radically transformed by relaxing these assumptions.

We now turn to the predictions of the many-good, many-factor HO model for the international location of production (the generalization of the Rybczynski Theorem). With an equal number of goods and factors of production and factor price equalization, the HO model implies a linear relationship between production and factor endowments. Estimating this relationship using cross-country data, Harrigan (1995) finds statistically significant coefficients on factor endowments, but large within-sample prediction errors, suggesting that the model performs poorly in explaining the international location of production. Gandal *et al.* (2004) and Hanson and Slaughter (2002) examine the HO model's prediction that, in an equilibrium where factor prices are pinned down by goods prices, changes in factor endowments should be absorbed through changes in output mix. Using immigration data for Israel and US states, they find some evidence in support of the model's prediction. More recent research reinforces conclusions from the analysis of net factor services trade by suggesting that non-neutral technology differences across industries are important for explaining the international location of production. In an influential paper, Harrigan (1997) estimates an equation for the share of sector in GDP derived from

the neoclassical model of trade, which relaxes the assumptions of the HO model to allow for cross-country differences in technology. Both differences in factor endowments and differences in technology that are non-neutral across industries are found to be important in explaining cross-country variation in production structure. Other research finds evidence consistent with multiple cones of diversification within the HO model, where countries or regions specialize in distinct set of goods, and as a result have different relative factor prices (Schott 2003 and Bernard *et al.* 2006).

We now turn to the relationship between international trade and factor prices, an issue which rose to prominence with the debate about whether the rise in wage inequality in OECD countries since the 1970s is explained by international trade or skill-biased technological change. While the labor economics literature has tended to emphasize the role of skill-biased technological change, the international trade literature has produced mixed findings, as illustrated by the collection of studies in Feenstra (2000). One approach has examined the net factor content of trade and has typically found a relatively minor role for international trade (see for example Krugman 2000). Another approach has examined the relationship between relative goods and relative factor prices within the many-good, many-factor version of HO model (the generalization of the Stolper-Samuelson Theorem). Here the results have been more sanguine about the contribution of international trade. Leamer (1998) showed how zero-profit conditions and the shares of factors in unit costs for a cross-section of industries can be used to estimate the changes in factor prices mandated by observed changes in goods prices. Making assumptions about the degree to which improvements in technology

are passed-through into lower goods prices, some evidence was found that trade-induced changes in goods prices during the 1970s pushed towards increasing wage inequality in the United States. Feenstra and Hanson (1999) developed a methodology for estimating the contribution of measures of technological change and outsourcing to changes in relative goods and hence through the zero-profit conditions to relative factor prices. In their baseline specification, they estimated that computers explained around 35% of the rise in the relative of U.S. non-production workers over the period 1979 to 1990 and outsourcing explained around 15%.

One important difference between international trade and other fields, such as development economics, is that general equilibrium is central to many of the field's theoretical predictions. As it result, it has proved hard to find natural experiments that provide plausible sources of exogenous variation to identify relationships of interest. Relatedly, many of the predictions of traditional trade theory with many-goods and many-factors relate to movements from autarky to international trade, but autarky is rarely observed. In two creative papers, Bernhofen and Brown (2004, 2005) exploit the dramatic opening of the Japanese economy in the nineteenth century from a state of near complete isolation to test some of the most fundamental predictions of general equilibrium trade theory. In their first paper, they find evidence supporting the general law of comparative advantage that an economy's net export vector evaluated at autarky prices is negative. In their second paper, they estimate that during the final years of Japan's isolation during 1851-3, real income would have had to increase by around 8-9 per cent in order to afford the consumption bundle that the economy

could have obtained if it were engaged in international trade during that period.

3. New Trade Empirics

Although traditional trade theory emphasizes the international exchange of one set of goods for another (inter-industry trade) due to comparative advantage (dissimilar countries), much of international trade involves the two-way exchange of goods within industries (intra-industry trade) between developed nations (similar countries). This apparent disconnect between theory and data was documented in a number of early empirical studies, which examined the extent of intra-industry trade (e.g. Grubel and Lloyd 1975) and the volume of trade between similar countries (e.g. Linder 1961). This empirical evidence was a key motivation for the “new trade theory” literature following Krugman (1979, 1980) that explained these features of international trade in terms of consumer love of variety and increasing returns to scale. Firms manufacture differentiated products and concentrate production in a single location, while consumers spread their expenditure across all firms’ varieties, giving rise to two-way trade even if countries are identical. Although not the only explanation for intra-industry trade between similar countries (see Davis 1997), the combination of consumer love of variety and increasing returns to scale provided an entirely new intellectual framework for thinking about the causes and consequences of international trade.

In the HO model, the volume of trade is increasing in the extent of dissimilarity in countries’ factor endowments, whereas in new trade theory

the volume of trade is increasing in the similarity of countries' sizes. Indeed, new trade theory provides rigorous theoretical foundations for the so-called "gravity equation", in which the volume of trade between two countries is proportional to the product of their sizes and measures of extent of trade frictions. Although the gravity equation had been known for some time to provide an extremely successful empirical explanation for bilateral patterns of international trade (classic early treatments include Tinbergen 1962 and Linnemann 1966), it initially suffered from a lack of theoretical foundations.

New trade theory's prediction that the volume of trade should be proportional to the similarity of country sizes was examined empirically by Helpman (1987) in specifications derived directly from the theory. Using data from 14 OECD countries over the period 1956 to 1981, both bilateral trade and the share of inter-group trade in total trade were found to be strongly increasing in the similarity of country sizes. While this appeared to strongly confirm the predictions of new trade theory, Hummels and Levinsohn (1995) found that the same patterns existed for trade between non-OECD countries, for whom new trade theory's assumptions of differentiated products and identical and homothetic preferences appeared less appropriate. One explanation why the gravity equation appears to work for such diverse groups of countries is that a number of alternative theoretical frameworks, including the HO model, yield this relationship. As argued by Deardorff (1998), the gravity relationship is a basic implication of specialization combined with identical and homothetic preferences. Therefore, the problem is not a lack but rather a surfeit of theoretical foundations. Consistent with this insight, Evenett and Keller (2002) found that

increasing returns and factor endowments both played a role in explaining the empirical success of the gravity equation for a diverse cross-section of developed and developing countries.

The gravity equation has been widely used in empirical work to estimate the impact on trade of a host of frictions, policies and institutions including national borders, transport costs, tariffs, common currencies and the World Trade Organization (WTO). A notable example is McCallum (1995), who found that trade between Canadian provinces was more than 20 times larger than trade between Canadian provinces and U.S. states, suggesting a surprisingly large impact of national borders on trade. Anderson and Van Wincoop (2002) showed, however, that theoretical derivations of the gravity equation imply bilateral trade depends not only on trade costs between regions themselves (“bilateral resistance”) but also on trade costs with all locations (“multilateral resistance”). An implication is that national borders have a larger impact on inter-regional trade relative to international trade, the smaller a country and the larger its trade partner. When countries are small, international trade is a large share of overall economic activity. Therefore, the national border has a large effect on multilateral resistance, and so leads to a large reduction in the cost of inter-regional trade relative to international trade. Estimating the gravity equation in a theory-consistent way, Anderson and Van Wincoop (2002) obtain much smaller, though still large, estimates of the trade impact of the Canada-U.S. border.

In the presence of trade costs, an important difference emerges between the predictions of new trade theory and those of traditional trade theory.

The combination of consumer love of variety, increasing returns to scale and trade costs in new trade theory generates a “home market effect” , where an increase in expenditure leads to a more than proportionate increase in domestic production of a good. The intuition is that increasing returns to scale imply that firms have an incentive to concentrate production, while transport costs imply that they have an incentive to concentrate production close to large markets. In contrast, traditional trade models imply that an increase in expenditure leads at most to a proportionate increase in domestic production if foreign export supply is perfectly inelastic. Otherwise, if the foreign export supply curve is upward sloping, some of the increase in expenditure is satisfied through higher foreign exports and the increase in domestic production is less than proportionate. Using international and Japanese regional data, Davis and Weinstein (1999, 2003) find evidence of home market effects for a number of manufacturing industries, which together account for a substantial share of overall manufacturing activity. Additional evidence in support of home market effects emerges from international trade data in Feenstra, Markusen and Rose (2001) and Hanson and Xiang (2004).

One feature of international trade that appears at first sight hard to reconcile with new trade theory is the large number of zeros between country pairs. The constant elasticity of substitution (CES) preferences and iceberg trade costs in new trade models imply that all country pairs trade a positive quantity of each variety. However, in an analysis of bilateral trade between 161 countries over the period 1970 to 1997, Helpman *et al.* (2006) find that roughly one half of the country-partner-year observations

involve zero trade. A natural explanation for zero bilateral trade flows can be created within new trade theory if firm heterogeneity and fixed trade costs are introduced following Melitz (2003). Depending on the distribution of productivity within countries, firms may or may not find it profitable to incur the fixed costs of exporting to a particular market. Helpman *et al.* (2006) develop a methodology for estimating the gravity equation that not only controls for multilateral resistance as suggested above, but also controls for the existence of zero bilateral flows and the non-random selection of firms into exporting according to their productivity.

Finally, one key stylized fact about international trade since the Second World War is that it has grown far more rapidly than income. Two potential explanations are reductions in trade barriers following multilateral liberalization or regional integration and improvements in transportation and communication technologies. Yi (2003) argues that is hard to explain the magnitude of the trade growth using standard trade models and observed declines in trade barriers unless one assumes implausibly high elasticities of substitution. However, augmenting standard models to include intermediate inputs enables the growth in trade to be explained with a smaller elasticity of substitution. In the augmented model, tariff reductions decrease the cost of shipping both intermediate inputs and final goods, and so have a magnified impact on overall trade volumes. Indeed, the geographical separation of stages of the production process is one of the distinctive features of trade at the end of the twentieth century compared with an earlier era of international integration at the end of the nineteenth century. This geographical separation of stages of production has been variously re-

ferred to as vertical specialization, vertical disintegration, the fragmentation of production, the slicing of the value-added chain, geographical production networks and offshoring. Hummels *et al.* (2001) define vertical specialization as occurring when the following conditions are satisfied: (a) goods are produced in multiple sequential stages; (b) two or more countries provide value-added in the good's production sequence; (c) at least one country uses imported inputs in its stage of the production process and some of the resulting output is exported. They provide empirical evidence of the rapid growth in vertical specialization in the closing decades of the twentieth century alongside the rapid growth in overall trade.

4. The Empirics of Product Trade

The dissemination of highly disaggregated datasets on trade in thousands of individual products (Feenstra *et al.* 2002, 2005) has contributed towards a shift in focus in empirical trade research towards the micro level. For the United States, data are available for over 7,000 seven-digit products of the Tariff Schedule of the United States (TS7) from 1972 to 1988 and for over 10,000 ten-digit products of the Harmonized System (HS10) from 1989 onwards.

In contrast to the empirical research on the HO model discussed above, which emphasizes specialization across products or industries, Schott (2004) provides compelling evidence of specialization *within* products. Taking U.S. manufacturing imports as a whole in 1994, and defining the unit value ratio (UVR) as the ratio of value to quantity, the maximum UVR within products across trade partners is a factor of 24 times greater than the minimum UVR.

The UVRs are higher for varieties originating in capital and skill-abundant countries than for those sourced from labor-abundant countries, consistent with HO-based specialization. Similarly, UVRs are positively associated with the capital intensity of the production techniques that exporters use to produce them. Taken together, these and other findings in the paper suggest that comparative advantage operates at a much finer level of detail than customarily considered.

Another insight that emerges from the product-level trade data is the importance of the “extensive margin” of the set of goods traded. Hummels and Klenow (2005) decompose variation in countries’ aggregate exports into the contributions of the following terms: (a) the quantity of each good exported (the “intensive margin”); (b) the set of goods exported (the “extensive margin”); (c) the quality of goods exported. They find that the extensive margin accounts for around 60 percent of the greater exports of larger economies, while the remaining intensive margin contribution of 40 percent consists of higher quantities being exported at modestly higher prices. Kehoe and Ruhl (2004) establish an important role for the extensive margin in explaining the growth of trade following trade liberalizations. The set of goods that accounted for only 10 percent of trade prior to liberalization are found to account for as much as 40 percent of trade after liberalization. Using micro data from the U.S. Commodity Flow Survey, Hillberry and Hummels (2005) show that trade frictions such as distance primarily reduce the aggregate value of trade through the number of commodities shipped and the number of establishments shipping commodities (the extensive margin) rather than through the average value of shipments

(the intensive margin). Together these findings raise a number of challenges for standard trade models. For example, in marked contrast to the data, new trade theory models without firm heterogeneity and fixed costs of trading imply that all of the adjustment to trade frictions occurs through the intensive margin.

Although consumer love of variety is one of the defining features of new trade theory, Broda and Weinstein (2006) were the first to estimate the welfare gains from an increase in the number of varieties imported over time. In their analysis, the product-level trade data is used to measure varieties, defined as the versions of a product supplied by different exporters. The methodology of Feenstra (1994) is extended to estimate separate elasticities of substitution for thousands of products and to evaluate the contribution of new varieties to the U.S. import price index. According to their baseline estimates, conventional price indices that do not correctly control for variety growth overstate the growth in U.S. import prices by around 1.2 percentage points per annum. The estimated contribution to U.S. welfare from an increase in the number of varieties imported over the period 1972 to 2001 is around 2.6 percent of national income.

5. The Empirics of Plant and Firm Trade

The analysis of micro datasets on plants and firms has raised additional empirical challenges for traditional and new trade theory and prompted a wave of subsequent theoretical research. The first set of empirical challenges relates to producer heterogeneity and persistent reallocation. Whereas traditional and new trade theories typically assume a representative firm,

micro datasets reveal vast heterogeneity across plants and firms within narrowly-defined industries, in terms of productivity, capital intensity, skill intensity and other characteristics (see for example the survey by Bartelsman and Doms 2000). Similarly, whereas traditional trade theory emphasizes net reallocations of resources between industries in response to exogenous shocks such as trade liberalization, micro datasets reveal persistent job creation and job destruction in all industries even in the apparent absence of exogenous shocks. Additionally, job creation and job destruction are positively correlated across industries, implying that rates of gross job creation and destruction are large relative to the net reallocation emphasized in traditional trade theory. An implication of these findings is that the changes in employment across plants and firms are greater than those required to achieve the observed between-industry reallocation of resources (“excess job reallocation”), implying substantial within-industry reallocations of resources (see in particular Davis *et al.* 1998).

The second set of empirical challenges relates to the export behavior of plants and firms. Traditional trade theory predicts net exports in one set of industries and net imports in another set of industries. New trade theory implies that all firms export as a result of consumer love of variety and increasing returns to scale. Yet, in micro datasets, all manufacturing industries display a mix of exporters and non-exporters (see Bernard and Jensen 1995). Moreover, exporters are systematically more productive, more capital-intensive and more skill-intensive than non-exporters (see again Bernard and Jensen 1995). These findings have led to considerable debate as to whether high-performing firms become exporters or whether

exporting leads to improved firm performance. The current consensus favors causality running from good firm performance to exporting (selection into export markets): see for example Bernard and Jensen (1999), Clerides et al. (1998) and Roberts and Tybout (1997).

The third set of empirical challenges relates to evidence from trade liberalizations in both developed and developing countries. Despite traditional trade theory's emphasis on between-industry reallocations of resources, one of the central findings from empirical studies of trade liberalizations is the importance of within-industry reallocations of resources across plants and firms. In an influential paper, Pavcnik (2002) finds that between-plant reallocations of resources account for around two thirds (12.4 percentage points) of the 19 percent increase in aggregate productivity in the Chilean manufacturing sector following the trade liberalization of the late 1970s and early 1980s. Similarly, Treffer (2004) finds an important role for reallocation in accounting for the improvement in aggregate productivity in Canadian manufacturing in the aftermath of the Canada-U.S. free trade agreement.

Together these empirical challenges have led to the development of new theoretical frameworks incorporating firm heterogeneity into both traditional and new trade theory (see in particular Bernard *et al.* 2003 and Melitz 2003). The interplay between the econometric analysis of micro datasets on plants and firms and the theoretical analysis of firm-based responses to international trade is one of the most exciting areas of ongoing research.

6. The Empirics of Trade Policy

A final area of rapid recent progress is the empirical analysis of trade policy. A number of alternative approaches to modelling the political economy of trade policy have been taken, including median-voter theories, models where the government trades off political support from industry against consumer dissatisfaction, theories of lobbying by special interest groups, and models of electoral contribution.

One of the most influential lines of research follows the seminal work of Grossman and Helpman (1994). In their model, campaign contributions are designed to influence policy choices. Interest groups move first and offer politicians campaign contributions that depend on their policy stance. Politicians next maximize a political objective function which depends on both campaign contributions and social welfare. The political objective function is derived from microeconomic foundations within a model of electoral competition. The model yields a structural equation in which the level of protection depends on the political organization of the industry, the ratio of domestic output in the industry to net trade and the elasticity of import demand or export supply. Goldberg and Maggi (1999) estimate the structural relationship implied by the Grossman and Helpman model and find broad empirical support. In particular, the pattern of protection differs markedly between politically organized and non-organized industries, though the implied weight on social welfare relative to political contributions is larger than expected. One of the distinctive features of recent empirical work in this area is again the rigorous derivation of empirical

specifications from theoretical predictions. Gawande and Krishna (2003) survey both the recent empirical evidence and the results of earlier and more *ad hoc* empirical specifications.

A related theoretical literature has sought to model the politics of international trade agreements (e.g. Grossman and Helpman 1995, Krishna 1998 and McLaren 2002). One issue that has attracted particular attention is the extent to which regional preferential trade agreements reinforce or retard multilateral trade liberalization. Theoretical research has also examined the microeconomic foundations for observed features of international trade institutions such as the General Agreement on Tariffs and Trade (GATT) and the World Trade Organization (WTO) (see in particular Bagwell and Staiger 1999, 2001). Two key features are reciprocity and non-discrimination (the Most Favored Nation (MFN) principle). Empirical work in this area remains in its infancy and offers an exciting prospect for the future. In an analysis of U.S. trade policy, Limao (2006) finds evidence that preferential trading blocs have acted as stumbling blocks for multilateral liberalization.

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