THE EMPIRICS OF FIRM HETEROGENEITY AND INTERNATIONAL TRADE

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ABSTRACT

This paper reviews the empirical evidence on firm heterogeneity in international trade. A first wave
of empirical findings from micro data on plants and firms proposed challenges for existing models
of international trade and inspired the development of new theories emphasizing firm heterogeneity.
Subsequent empirical research has examined additional predictions of these theories and explored
other dimensions of the data not originally captured by them. These other dimensions include multi-product
firms, offshoring, intra-firm trade and firm export market dynamics.

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1 Introduction

Research in international trade has changed dramatically over the past fifteen years as its focus has shifted from industries and countries to firms and products. This transformation was instigated by the emergence of a wide range of "micro"-datasets exhibiting sharp variation in firm outcomes and attributes, even within narrow industries. Models developed in reaction to this challenge both rationalize this heterogeneity and offer new insight into the ways in which economies respond to international trade. For example, the well-known gravity equation relationship between aggregate trade and distance is largely accounted for by the extensive margin of the number of heterogeneous firms and products participating in trade rather than the intensive margin of the amount traded per firm and product.

One of the most striking features of the microdata is that firm participation in international trade is exceedingly rare. Researchers find that exporters and importers represent just a tiny fraction of producers across many developed and developing economies. This participation is far from random. Indeed, the same studies find that exporters and importers are larger, more productive, more skill- and capital-intensive, and pay higher wages prior to their entry into international markets than non-trading firms. These facts suggest self-selection: exporters are more productive, not necessarily as a result of exporting, but because only the most productive firms are able to overcome the costs of entering export markets. The most successful model of such selection is the seminal Melitz (2003) model, which has dominated recent research in the field. The key insight of that model is that micro-heterogeneity influences aggregate outcomes. When trade policy barriers or transportation costs fall, high-productivity exporting firms survive and expand while lower-productivity non-exporting firms shrink or exit. This reallocation of economic activity across firms raises aggregate productivity, an effect of globalization that was largely neglected in previous theories of international trade based on comparative advantage and consumer love of variety.

Much of recent theoretical research in international trade has focused on generalizing or elaborating on this basic model of selection. Studies have explored the interaction between comparative advantage and heterogeneous firms (Bernard et al. 2007a), variable mark-ups and market size (Melitz & Ottaviano 2008), country asymmetries (Arkolakis et al. 2008), multi-product firms (Bernard et al. 2011, Eckel & Neary 2010, Mayer et al. 2011), the decision whether to organize production activities within or beyond the boundaries of the firm (Antràs & Helpman 2004, 2008), managerial hierarchies within the firm (Caliendo & Rossi-Hansberg 2011), labor market frictions (Amiti & Davis 2011, Egger & Kreickemeier 2009, Helpman and Itskhoki 2010, and Helpman et al. 2011), and financial constraints (Chaney 2005, Manova 2011), among other issues.[1]

We begin by reviewing the empirical challenges to traditional theories of international trade that emerged from micro data on plants and firms (Section 2). We next briefly discuss the development of theories of heterogeneous firms that have shaped much subsequent empirical research (Section 3). More recently, the

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[1]For reviews of the theoretical literature on heterogeneous firms and trade, see Helpman (2006) and Redding (2010).

availability of microdata on individual trade transactions within the firm has stimulated empirical research on a whole host of new topics, including the extensive and intensive margins of trade (Section 4), multi-product firms (Section 5), firm importing (Section 6), product quality (Section 7), intermediaries (Section 8), foreign direct investment (Section 9), intra-firm trade (Section 10), labor markets (Section 11), and firm export market dynamics (Section 12).

2   Empirical Challenges to Existing Trade Theories

Traditional (or "old") theories of international trade emphasize comparative advantage - that is variation in opportunity costs of production across countries and industries - as the basis for international trade. In these theories, international commerce takes the form of *inter-industry trade*, where countries export goods in one set of industries and import goods in another set of industries. More recent (or "new") theories of international trade instead focus on increasing returns to scale and consumer love of variety as the basis for international trade, as in Krugman (1980), Helpman (1981) and Ethier (1982). These theories provide a natural explanation for *intra-industry trade*, where countries both export and import goods within the same industry. The two theories were combined within the integrated equilibrium approach of Helpman & Krugman (1985). When suitably augmented to allow for technology differences and cross-country variation in factor prices, they provided a relatively successful explanation for patterns of trade across countries and industries, as reviewed in Helpman (1999). A key simplification in this theoretical literature was the assumption of a representative firm within each industry. With the increased availability of micro datasets on firms and plants from the late 1980s and 1990s onwards, it became clear that there was in fact vast heterogeneity across producers within industries, in terms of size, productivity, capital and skill-intensity, and wages. Furthermore an emerging empirical literature began to explore the idea that this heterogeneity was systematically related to trade participation in ways that could be influential for aggregate outcomes.

2.1   Export Participation

Bernard & Jensen (1995) present evidence for U.S. manufacturing showing that typically a minority of plants within an industry export. As illustrated in Table 1, which is taken from Bernard et al. (2007b) and uses data from the 2002 U.S. Census of Manufactures, the overall share of U.S. manufacturing firms that export is relatively small at 18 percent (column 3). But there is considerable variation in export market participation rates across industries within manufacturing: the share of exporters ranges from 38 percent in Computer and Electronic Products to only 8 percent in Apparel. These exporting firms also ship a relatively small share of their total shipments abroad. As shown in column 4, the average share of shipments exported is 14 percent for the manufacturing sector as a whole. But again there is substantial variation across industries: from 21 percent in Computers to 7 percent in Beverages. While the results here use U.S. data, similar findings have

emerged for a wide range of other countries, as summarized for example in Mayer & Ottaviano (2007) and World Trade Organization (2008).

2.2 Exporter Characteristics

The first wave of microdata research demonstrated that not only is exporting rare but exporters are systematically different from non-exporters. Bernard & Jensen (1995) show that among U.S. manufacturing plants, exporters are larger, more skill intensive, more capital intensive, and more productive. Table 2, also from Bernard et al. (2007b), highlights these differences for manufacturing firms. Each row of the table summarizes the average percent difference between exporters and non-exporters for a particular characteristic.

As shown in the first column, there are substantial mean differences between exporters and non-exporters. On average, exporting firms are larger in employment and sales, more productive, and use a different input mix. Since export participation is correlated with industry characteristics, the inclusion of industry effects in the second column typically reduces the magnitude of these coefficients. But exporters remain different from non-exporters even within the same disaggregated industry: they are 97 percent larger in employment and 108 per cent larger in shipments; they are more productive by 11 per cent for value-added per worker and 3 per cent for total factor productivity; they also pay higher wages by around 6 percent. Finally, exporters are relatively more capital- and skill-intensive than non-exporters by approximately 12 and 11 percent, respectively.

While the correlation between firm size and exporting accounts for some of the differences between exporters and non-exporters, they remain even after controlling for log employment, as shown in the third column. Qualitatively similar results have been found for many other countries and time periods.[2]

The finding that U.S. exporters are more capital- and skill-intensive is consistent with "old" trade theory forces of comparative advantage being at work within industries. If a firm's factor intensity reflects the nature of the products it supplies, then firms which are more capital- and skill-intensive are supplying products that are more consistent with U.S. comparative advantage (Bernard et al. 2006b).

More difficult to square with old trade theory concepts of comparative advantage are empirical findings that exporters are also more capital- and skill-intensive in developing countries, which are plausibly abundant in unskilled labor (Alvarez & Lopez, 2005). If exporting firms in these countries were supplying products consistent with comparative advantage, they would be labor-intensive rather than capital- and skill-intensive. Potential explanations for findings that exporters are more capital- and skill-intensive in both developed and developing countries include technology-skill complementarity, as explored in Burstein & Vogel (2010), Harrigan & Resheff (2011) and Sampson (2011), and sorting by product quality within industries as in

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[2]Similar differences in performance are observed between firms shipping to remote versus proximate locations within the U.S., as shown in Holmes & Stevens (2010).

Verhoogen (2008).[3]

2.3 Sunk Costs and Selection into Exporting

The finding that exporters are more productive than non-exporters raises the question of the direction of causality: does high productivity induce firms to self-select into export markets or does exporting cause productivity growth through "learning by exporting." An extensive body of research for many industries and countries confirms that high productivity precedes entry into export markets. These findings are suggestive of sunk costs of entry into export markets that only the most productive firms find it profitable to incur, as emphasized in Roberts & Tybout (1997). Whether there is also learning by exporting is less clear. Early studies by Clerides et al. (1998) using data for Mexico, Colombia and Morocco and Bernard & Jensen (1999) using U.S. data found no evidence of differences in productivity growth between exporters and non-exporters. Most research confirms these findings, however, some studies have found evidence of productivity improvements following export market entry, such as Van Biesebroeck (2005) and de Loecker (2007). Other recent research has provided evidence that export market entry may increase the return to other complementary investments such as technology adoption, as examined theoretically in Atkeson & Burstein (2010), Burstein & Melitz (2011), Constantini and Melitz (2008) and shown empirically in Bustos (2011), Lileeva & Trefler (2010) and Aw et al. (2011).

2.4 Trade Liberalization, Reallocation, and Productivity Growth

Empirical analyses using microdata on plants and firms reveal new channels through which trade liberalization can affect the aggregate economy. Beyond the effects of the expansion in the range of product varieties available to consumers, there exists the potential for within-industry productivity growth arising from decreasing trade costs. Trade liberalization reforms are typically accompanied by the contraction and exit of low-productivity firms and the expansion and entry into export markets of high-productivity firms. This reallocation of resources within industries raises average industry productivity.

Additionally, trade liberalization can have a "pro-competitive" effect in reducing mark-ups of price over marginal cost, so that trade liberalization reduces average prices through both lower average costs and lower average mark-ups. These reductions in average prices in turn provide sources of welfare gain.

In the context of the Chilean trade liberalization, Pavcnik (2002) finds that roughly two-thirds of the 19 percent increase in aggregate productivity is due to the relatively greater survival and growth of high-productivity plants. A similar pattern of results is found in a large number of studies of trade liberalization reforms in developing countries, as surveyed in Tybout (2003). Within-industry reallocations of resources in these studies typically dominate cross-industry reallocations of resources.

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[3]More broadly, for a theoretical analysis of the idea that international trade is inherently more skill-intensive than domestic production, see Matsuyama (2007).

One concern is that trade liberalization often occurs as part of a wider package of reforms. However, similar patterns of productivity gains from the expansion of high-productivity exporting firms have been found in response to reductions in trade barriers in both Canada (Trefler, 2004) and the United States (Bernard et al. 2006a). For example, Trefler (2004) finds effects of Canadian tariff reductions on industry productivity that are roughly twice as large as those on plant productivity, implying market share reallocations favoring high-productivity plants.

Another source of aggregate productivity growth following trade liberalization is improvements in productivity within plants or firms. In Pavcnik (2002), around one-third of the increase in aggregate productivity following the Chilean liberalization was due to within-plant productivity gains. Similarly, in Trefler (2004), the Canada-U.S. Free Trade Agreement is found to raise the labor productivity of Canadian manufacturing plants by 7.4 percent or by an annual compound growth rate of 0.93 percent. These improvements in plant or firm productivity may be themselves the result of reallocations across disparate economic activities within the plant or firm, as discussed further below.

3   Heterogeneous Firm Theories

The empirical challenges to old and new trade theory from microdata have led to the development of recent theories of firm heterogeneity and international trade. These theories not only account for the features of disaggregated trade data noted above, but also yield additional predictions that have been the subject of further empirical work. The seminal study of Melitz (2003) introduces firm heterogeneity into Krugman's (1980) model of intra-industry trade to yield a tractable and flexible framework that has become a standard platform for analyzing a host of issues in international trade.[4]

In Melitz (2003), there is a competitive fringe of potential firms who can enter an industry by paying a fixed entry cost which is thereafter sunk. Potential entrants face *ex ante* uncertainty concerning their productivity. Once the sunk entry cost is paid, a firm draws its productivity from a fixed distribution and productivity remains fixed thereafter. Firms produce horizontally differentiated varieties within the industry under conditions of monopolistic competition. The existence of a fixed production cost implies that firms drawing a productivity level below the "zero-profit productivity cutoff" would make negative profits and therefore exit the industry. Fixed and variable costs of exporting ensure that only those active firms that draw a productivity above a higher "export productivity cutoff" find it profitable to export.[5]

In this model, a symmetric reduction in trade barriers between all countries has a number of implications for industry equilibrium. High-productivity exporting firms experience increased revenue through greater

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[4] An alternative framework for modeling firm heterogeneity is Bernard et al. (2003), which considers Bertrand competition in the stochastic multi-country Ricardian model of trade of Eaton & Kortum (2002). Another approach is pursued in Yeaple (2005), in which firms are *ex ante* identical, but firm heterogeneity emerges *ex post* through the endogenous allocation of heterogeneous workers across firms.

[5] For empirical evidence of sunk costs of exporting, see Roberts & Tybout (1997), Bernard & Jensen (2004), and Das et al. (2007).

export market sales. The most productive non-exporters now find it profitable to enter export markets, thereby increasing the fraction of exporting firms. In contrast, low productivity firms exit and there is a contraction in the revenues of surviving firms that only serve the domestic market. Each of these responses reallocates resources towards high-productivity firms and raises aggregate productivity through a change in industry composition.

This theoretical framework addresses a number of the empirical challenges from microdata. Together firm heterogeneity and fixed exporting costs imply that only some firms export and these exporters are more productive than non-exporters. The productivity advantage of exporting firms reflects self-selection into export markets rather than learning by exporting. Finally, the self-selection of firms into export markets ensures that trade liberalization has uneven effects on low and high-productivity firms and hence raises aggregate productivity through a change in industry composition.

While the assumption of constant elasticity of substitution (CES) preferences in Melitz (2003) ensures constant firm mark-ups of price over marginal cost, Bernard et al. (2003) and Melitz & Ottaviano (2008) develop models of firm heterogeneity in which firm mark-ups are endogenous. In such settings, trade liberalization can have a pro-competitive effect in reducing the price charged by a given firm through a lower mark-up of price over marginal cost. In models with variable mark-ups, a firm with a given productivity can also charge different mark-ups in the domestic and export markets. Using Slovenian data, De Loecker & Warzynski (2011) provides empirical evidence of differences in mark-ups between exporters and non-exporters and discusses the implications of such variable mark-ups for estimated productivity differences between exporters and non-exporters.

In Bernard et al. (2007a), heterogeneous firms are integrated into the standard trade paradigm of Helpman & Krugman (1985). The resulting framework simultaneously explains why some countries export more in certain industries than in others (endowment-driven comparative advantage), why two-way trade is observed within industries (firm-level horizontal product differentiation combined with increasing returns to scale), and why, within industries, some firms export and others do not (self-selection driven by trade costs). Consistent with the empirical findings reported in Table 1, the fraction of exporting firms and the share of exports in firm shipments vary systematically with comparative advantage.

4   Gravity and the Extensive and Intensive Margins

One of the most successful empirical relationships in economics is the gravity equation, which relates the value of total bilateral trade between countries to their economic size and the variable trade costs between them. Under the assumption that firm productivity is Pareto distributed, the Melitz (2003) model yields a

gravity equation for total bilateral trade flows, as shown in Chaney (2008) and Arkolakis et al. (2008).[6] One remarkable feature of this gravity equation is that the elasticity of trade flows with respect to variable trade costs depends not on the elasticity of substitution between firm varieties but rather on the shape parameter of the Pareto distribution for productivity.

The intuition for this result can be garnered by noting that aggregate bilateral trade between any two countries (X_{ij}) can be decomposed into the *extensive margin* of the number of exporting firms (M_{ij}) and the *intensive margin* of average firm exports conditional on exporting (X_{ij}/M_{ij}):

$$X_{ij} = M_{ij} \left(\frac{X_{ij}}{M_{ij}} \right). \tag{1}$$

In the Melitz model, an increase in variable trade costs has two offsetting effects on the intensive margin.[7] On the one hand, higher variable trade costs reduce the value of exports of a given exporter, which *reduces* average firm exports. On the other hand, higher variable trade costs imply that some exporters who were previously close to the productivity threshold for exporting can no longer generate sufficient variable profits to cover the fixed costs of exporting and exit the export market. Since these exiting exporters have smaller export values than surviving exporters, this *raises* average firm exports through a change in composition. In the special case of a Pareto distribution, these two effects exactly offset one another, leaving the intensive margin independent of variable trade costs. As a result, variable trade costs only affect bilateral trade through the extensive margin, and the elasticity of this extensive margin with respect to variable trade costs is determined by the shape parameter of the Pareto distribution for productivity.

The special case of the Melitz (2003) model with a Pareto distribution for productivity lies within the class of theoretical models considered by Arkolakis et al. (2011a), in which a country's share of trade with itself is a sufficient statistic for the welfare gains from opening the closed economy to trade. While empirical studies have sought to quantify the contributions of particular sources of welfare gains, such as product variety in Broda & Weinstein (2006), this theoretical analysis implies that the various sources of welfare gains are related to one another in general equilibrium and that the overall effect of trade on welfare can be determined simply from a country's share of trade with itself. See also Atkeson and Burstein (2010) for a theoretical analysis of the relationship between the various possible sources of welfare gains from trade in heterogeneous firm models.

A key implication of the Melitz (2003) model is that the extensive margin of the number of exporting firms should vary systematically with export market size, since in larger markets firms of lower productivity can generate sufficient variable profits to cover the fixed costs of exporting. Using French export data by

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[6] For empirical evidence that the Pareto distribution provides a reasonable approximation to the observed distribution of firm sizes, see for example Axtell (2001).

[7] We define the intensive margin as average firm exports conditional on exporting because it facilitates the decomposition of average exports in (1) and has a straightforward empirical implementation. Chaney (2008) instead defines the intensive margin as exports of a given firm to a given destination, in which case the intensive margin is unaffected by composition.

firm and destination market, Eaton et al. (2004, 2011a) establish this and a number of other empirical regularities. First, the number of French firms selling to a market (relative to French market share) increases with market size according to an approximately log linear relationship. Second, this pattern of firm export market participation exhibits an imperfect hierarchy, where firms selling to less popular markets are more likely to sell to more popular markets, but do not always do so. Third, export sales distributions are remarkably similar across markets of very different size and extent of French participation. While the upper tail of these distributions is approximately Pareto distributed, there are departures from a Pareto distribution in the lower tail where small export shipments are observed. Fourth, average sales in France are higher for firms selling to less popular foreign markets and to more foreign markets.

To explain these empirical regularities, Eaton et al. (2011a) consider an augmented version of the Melitz model with a Pareto productivity distribution. To generate departures from a Pareto distribution of export sales in the lower tail where small export shipments are observed, the fixed costs of entering each export market are allowed to vary endogenously with a firm's choice of the fraction of consumers within that market to serve, as in the marketing costs formulation of Arkolakis (2010). To incorporate imperfect hierarchies of markets, the fixed costs of entering export markets are assumed to be subject to an idiosyncratic shock for each firm and destination market. To allow for idiosyncratic variation in export sales conditional on entering a given export market for firms with a given productivity, demand is also subject to an idiosyncratic shock for each firm and destination market. While a firm's decision to enter an export market depends on a composite of the market entry and demand shocks, a firm with a given productivity can enter a market because of a low entry shock and yet still have low sales in that market because of a low demand shock.

The properties of the model depend on five key parameters: (i) a composite parameter that includes both the elasticity of substitution and the Pareto shape parameter, (ii) the convexity of marketing costs, (iii) the variance of demand shocks, (iv) the variance of entry shocks, and (v) the correlation between demand and entry shocks. Eaton et al. (2011a) use simulated method of moments to estimate these parameters using moments of the French export data by firm and destination market. The five parameters are precisely estimated and the parameterized model is shown to provide a good fit to the observed data. For the estimated parameter values, firm productivity accounts for around half of the observed variation across firms in export market participation, but explains substantially less of the variation in exports conditional on entering a market.

Given the estimated parameter values, the model can be used to examine counterfactuals, such as a 10 percent reduction in bilateral trade barriers for all French firms. In this counterfactual, total sales by French firms rise by around $16 million, with most of this increase accounted for by a rise in sales of the top decile of firms of around $23 million. In contrast, every other decile of firms experiences a decline in sales, with around half of the firms in the bottom decile exiting. Taken together, these results suggest that the intra-industry

reallocations emphasized by theories of heterogeneous firms and trade can be quantitatively large, even for empirically reasonable changes in trade frictions.[8]

Heterogeneous firm theories also shed light on the prevalence of zeros in bilateral trade flows. Using data on trade between 158 countries from 1970-97, Helpman et al. (2008) find that around one half of the country pairs do not trade with one another. Motivated by this feature of the data, they develop a multi-country version of the Melitz (2003) model, in which firm productivity is drawn from a truncated Pareto distribution. In this framework, no firm exports between a pair of countries if the productivity threshold for exporting exceeds the upper limit of the productivity distribution in each country. Estimating a gravity equation derived from the model, they show that controlling for both the non-random selection of positive trade flows and the extensive margin of exporting firms has quantitatively important implications for estimates of the effects of standard trade frictions on trade flows. Of these two corrections, controlling for the extensive margin of the number of heterogeneous firms that export is quantitatively more important than controlling for the non-random selection of positive trade flows.[9]

Although most research on heterogeneous firms and trade assumes a continuum of firms, Eaton et al. (2011b) argue that the existence of a finite number of firms provides an alternative potential explanation for zero bilateral trade flows. Even if the productivity distribution is unbounded from above, the existence of a finite number of firms implies that there is a positive probability that no firm draws a productivity above the threshold for exporting between a pair of countries. Using data on bilateral trade in manufactures among 91 countries, they show that the model accounts for the pattern of zero trade flows while maintaining the good fit of the standard gravity equation among country pairs with positive trade flows.

5   Multi-product Firms

One of the striking features of international trade data is the extent to which international trade is concentrated in the hands of a few firms. As reported in Bernard et al. (2009a), the top 1 percent of firms account for around 90 percent of the value of U.S. trade, even though they account for only around 15 percent of employment. Similar levels of concentration are observed in other countries, as summarized in World Trade Organization (2008).

One reason why international trade is so concentrated is that larger exporters not only export more of a given product to a given destination than smaller exporters, but also export more products to more destinations. Table 3, from Bernard et al. (2007b), reports the distribution of exporters, export value and employment by the number of products and export destinations. Around 40 percent of exporting firms export

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[8]Other quantitative analyses of models of firm heterogeneity and trade include the study of trade integration in Corcos et al. (2010), the analysis of the impact of China's productivity growth on world welfare in Hsieh & Ossa (2010), and the investigation of patterns of trade in Bangladesh's apparel sector in Cherkashin et al. (2010).

[9]Santos Silva and Tenreyro (2006) consider an alternative approach to zero trade flows that uses the Poisson fixed effects estimator.

a single product to a single destinations (panel A), but these firms account for less than 1 percent of export value (panel B). In contrast, the 12 percent of firms that export more than five products to more than five destinations account for more than 90 percent of export value.

To make sense of firms' decisions over the extensive margins of products and destinations, Bernard et al. (2011) develop a model of multi-product, multi-destination firms that is a generalization of Melitz's (2003) framework. In order to enter, firms incur a sunk entry cost, which reveals their ability. Firms then choose among a continuum of products and many export markets. Firm profitability depends upon the interaction of firm ability, which is common across products, and firm-product attributes, which are idiosyncratic across products and possibly also across export destinations. Firms face fixed costs in serving each market and in supplying each product to each market. Higher ability firms can generate sufficient variable profits to cover the product fixed cost at a lower value of product attributes and hence supply a wider range of products to each market. For sufficiently low values of firm ability, the excess of variable profits over product fixed costs in the small range of profitable products does not cover the fixed cost of serving the market and therefore the firm does not supply the market. The lowest-ability firms exit, intermediate-ability firms serve only the domestic market and the highest ability firms export. Within exporters, products with the worst attributes are supplied only to the domestic market, while products with the best attributes are exported to the largest number of markets.

While the standard heterogeneous-firm model emphasizes selection *across* firms, this model also emphasizes selection *within* firms. Selection within firms provides a potential rationale for the effects of trade liberalization on within-firm productivity found in the empirical studies discussed above, since trade liberalization induces firms to drop their least successful products with low revenue productivity. Using data from the Canada-U.S. Free Trade Agreement (CUSFTA), Bernard et al. (2011) and Baldwin & Gu (2009) provide empirical evidence of product rationalization following trade liberalization.

The extensive margins highlighted by models of multi-product firms have important implications for the mechanisms underlying aggregate economic relationships. Aggregate bilateral trade between any two countries (X_{ij}) can be decomposed into the *extensive margin* of the number of firm-product observations with positive exports (O_{ij}) and the *intensive margin* of average firm-product exports conditional on positive trade ($\bar{x}_{ij} = X_{ij}/O_{ij}$):

$$X_{ij} = O_{ij}\bar{x}_{ij}, \qquad \bar{x}_{ij} \equiv \left(\frac{X_{ij}}{O_{ij}}\right), \tag{2}$$

where the number of firm-product observations with positive trade can be decomposed in turn into the extensive margins of the number of exporting firms (M_{ij}), the number of exported products (N_{ij}) and a density term ($D_{ij} = O_{ij}/(M_{ij}N_{ij})$) that captures the extent to which each firm exports each product:

$$O_{ij} = M_{ij}N_{ij}D_{ij}, \qquad D_{ij} \equiv \left(\frac{O_{ij}}{M_{ij}N_{ij}}\right). \tag{3}$$

Table 4 reports the results of estimating gravity equations for aggregate U.S. exports and each of the extensive and intensive margins in (2) and (3). The table is taken from Bernard et al. (2011) and destination market size and variable trade costs are proxied using destination market GDP and geographical distance respectively. The well-known negative effect of distance on aggregate bilateral trade (column 1) is entirely accounted for by the extensive margin of the number of firm-product observations with positive trade (column 3). In contrast, distance has a positive but statistically insignificant effect on the intensive margin of average exports per firm-product conditional on positive trade (column 2). The extensive margins of the number of exporting firms and the number of exported products both decline with distance (columns 4 and 5). The opposite is true of density, because each firm is active in a limited subset of products, which implies that the number of firm-product observations with positive trade (O_{ij}) increases less than proportionately than the number of firms times the number of products ($M_{ij}N_{ij}$).

The theoretical model discussed above provides a natural explanation for these empirical findings. A reduction in variable trade costs lowers product prices in each export market which increases revenue and variable profits. Reductions in variable trade costs raise aggregate exports through the share of products exported to a given country by incumbent exporters (within-firm product extensive margin), an increase in the average number of countries to which a given product is supplied by incumbent firms (within-firm country extensive margin), and the entry of lower-ability firms that previously only served the domestic market into export markets (the across-firm extensive margin). In contrast, selection within firms implies that reductions in variable trade costs have ambiguous effects on the intensive margin of average exports per firm-product, because they increase exports of a given firm and product, but induce entry into export markets of firms and products with smaller export values.

A growing theoretical and empirical literature in international trade has investigated a variety of implications of multi-product, multi-destination firms. While early contributions such as Ottaviano & Thisse (1999) and Allanson & Montagna (2005) modeled firms and products symmetrically, more recent research has explored the idea that firms have core competences. Eckel & Neary (2010) consider a model of flexible manufacturing where each firm faces rising marginal costs in producing products further from its core competence. Firms are large relative to the market and hence face a cannibalization effect, where introducing additional products diminishes the demand for the firm's existing products.[10] Javorcik et al. (2010) consider an augmented version of this model, in which firms can make endogenous investments in the quality of each product and in their overall brand. Using Mexican trade transaction data, they provide empirical evidence in support of the model's key predictions for the relationship between product prices and sales rank within the firm.

Other recent research has concentrated on monopolistically-competitive models of multiple-product firms

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[10]See also Feenstra & Ma (2008) and Dhingra (2010).

without cannibalization effects. In Mayer et al. (2011), firms face a product ladder, where productivity/quality declines discretely for each additional variety produced. Together with variable mark-ups, this generates the prediction that firm sales are more skewed towards core competences in more competitive markets. French export data provide strong empirical support for this prediction of the model. In Arkolakis & Muendler (2010), firms face declining productivity for each additional variety supplied to a market and market entry costs that are increasing in the number of varieties supplied to a market. Using Brazilian trade transaction data, they present evidence in support of the model's prediction of a positive relationship between the number of products that a firm exports to a market and average exports per product. In contrast, in Nocke and Yeaple (2006), firms with higher organizational capability produce more products and have higher marginal costs for all products, which generates a negative relationship between firms' extensive and intensive margins.

While most of the above research concentrates on the determinants of the products and destinations supplied by multi-product firms at a given point time, there is evidence that product market entry and exit within surviving firms is influential for firm, industry and aggregate dynamics over time. Using U.S. Census of Manufactures data, Bernard et al. (2010a) find that around one half of surviving U.S. firms add and/or drop products from their existing range every five years, and the contribution of these added and dropped products to aggregate output is of around the same magnitude as the contribution of firm entry and exit.[11] Consistent with a natural generalization of models of industry dynamics to incorporate selection with firms, the probability that a product is dropped within a surviving firm exhibits the same pattern of age and scale dependence as the probability that a firm exits. Taken together, these findings suggest that reallocation may be even more important than hitherto thought, in so far as it occurs across products within firms as well as across firms.

6 Firm Importing

The early empirical literature on firm heterogeneity in international trade concentrated almost exclusively on firm export behavior, since only exporting information was recorded in censuses of domestic production or manufacturing. More recent work using firm-level trade transaction data has begun to examine heterogeneity in firm import behavior.

Firm importing displays many of the same features as firm exporting. Bernard et al. (2007b) find that, for U.S. manufacturing firms, importing is somewhat rarer than exporting and there is substantial variation across industries. The shares of exporting and importing firms are significantly positively correlated (0.87) across industries. Around 41 percent of exporters also import while 79 percent of importers also export. The

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[11]The production of multiple products complicates the measurement of firm productivity when separate data on outputs, inputs and prices are not available at the firm-product level, as considered in Bernard et al. (2009c) and De Loecker (2011).

share of export-only firms is positively and significantly correlated with industry skill intensity, while the share of import-only firms is negatively but not significantly correlated with industry skill intensity.

Importers exhibit a number of the same performance differences as exporters. As reported in Table 5 from Bernard et al. (2007b), importers are bigger, more productive, pay higher wages and are more skill- and capital-intensive than non-importers. From a comparison of the first and second columns with the third column, the performance differences between firms that participate in international trade and those that do not are partly driven by firms that both import and export, which exhibit the largest performance differences from domestic firms. These findings suggest that trade liberalization is likely to benefit the largest, most productive, most skill- and capital-intensive firms within industries, not only through enhanced access to export markets, but also through improved availability of imported intermediate inputs.

While empirical studies of the impact of trade liberalization on productivity have typically focused on reductions in tariffs in output markets, more recent evidence suggests that reductions in tariffs on imported intermediate inputs may be a prominent source of productivity gains. Amiti & Konings (2007) use manufacturing census data from Indonesia, which contains plant-level information on imported intermediate inputs, to construct separate measures of input and output tariffs. Following the trade liberalization that occurred in the 1990s, they find that reductions in input tariffs are associated with an increase in productivity of around 12 percent for firms that import their inputs, which is around twice as large as the effect for reductions in output tariffs.

Input tariffs may affect productivity through a number of potential channels, including learning about foreign technologies, expansion in the variety of intermediate inputs available for production, and access to higher-quality intermediate inputs. Following India's trade liberalization in the early 1990s, Goldberg et al. (2010) find that around two thirds of the growth in imports of intermediate inputs is accounted for by the extensive margin of newly imported products. In industries that experienced greater tariff reductions, there is a larger increase in total value, a greater reduction in prices and a larger expansion in variety of imported intermediate inputs. Consistent with the idea that the availability of new intermediate inputs expanded the technological possibilities of firms, industries that saw greater increases in the variety of imported intermediate inputs also experienced greater increases the range of products produced by Indian firms.

More generally, the presence of both importing and exporting within firms suggests the relevance of theories of the "fragmentation of production," such as Dixit & Grossman (1982) and Grossman & Rossi-Hansberg (2008). In these models, firms can organize stages of production across national borders. Using input-output tables for 10 OECD and four emerging-market countries, Hummels et al. (2001) estimate that such vertical specialization accounts for around 20 percent of countries' exports and grew by around 30 percent between 1970 and 1990. As shown in Yi (2003), when stages of production are spread across national boundaries in this way, changes in trade costs can have a magnified impact on trade flows, because they are

incurred each time the good is traded back and forth between countries.[12]

7   Product Quality

Even within narrowly-defined product categories, such as the 8,000+ products of the ten-digit Harmonized System (HS) classification, there is tremendous variation in unit values across trade partners. A growing literature in international trade argues that this variation in prices reflects differences in product quality across trade partners, as in Schott (2004) and Hummels & Klenow (2005).[13] Furthermore, this variation in prices is strongly related to country endowments, with more capital and skill-abundant countries supplying varieties with higher prices within narrow product categories. According to this view, capital and skill-abundant countries use their endowments to supply products of higher quality, and this higher product quality is reflected in a higher price.

Many papers use microdata to study the relationship between price variation and trade patterns at the firm level. For instance, Manova and Zhang (2011) use Chinese trade transaction data to highlight a number of systematic features of exports and imports by firm, product and destination that are consistent with heterogeneity in product quality.[14] For example, across firms selling a given product, firms that charge higher export prices earn greater revenues in each destination, have bigger worldwide sales, and export to more markets. Across destinations within a firm-product, firms set higher prices in richer, larger, bilaterally more distant and overall less remote countries. Finally, firms that export pay a wider range of input prices and source inputs from more countries. Taken together these features of the data are consistent with a heterogeneous firm model where more successful exporters use higher-quality inputs to produce higher-quality goods and firms vary the quality of their products across destinations.

Using Colombian census of manufactures data, Kugler & Verhoogen (2011) provide evidence of differences in product quality and highlight the relationship between firm export and import decisions. Within narrowly defined industries, larger firms charge more for their outputs and pay more for their inputs than smaller firms, and similar differences exist between exporters and non-exporters. This pattern of results is consistent with an extension of Melitz (2003), in which firms endogenously choose both input and output quality and there is a complementarity between the quality of inputs and outputs.

In Melitz (2003), the assumptions of constant elasticity of substitution (CES) preferences and monopolistic competition imply that firm productivity and product quality are isomorphic in the sense that they enter equilibrium firm revenue in exactly the same way. An empirical literature has sought to distinguish productivity and product quality by exploiting variation in prices across firms on the grounds that higher

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[12]For a discussion of how global supply chains influenced the impact of the recent earthquake and tsunami in Japan, see Economist (2011).

[13]For evidence on the role of product quality in explaining patterns of bilateral trade, see Hallak (2006).

[14]See also Bastos and Silva (2008) for evidence using Portuguese trade transaction data.

productivity implies lower prices whereas higher product quality can lead to higher prices, as explored in Baldwin & Harrigan (2011) and Johnson (2010).

One empirical challenge facing this literature is that firms supply horizontally differentiated varieties in Melitz (2003) and the specification of consumer preferences in which all varieties enter utility symmetrically implicitly imposes a choice of units in which to measure the quantity of each variety. There is no necessary relationship between this normalization and the units in which physical quantities of output are measured for each firm in the data. As a result, data on physical quantities of output cannot be directly compared across firms in the presence of horizontal product differentiation, which complicates the interpretation of variation in unit values across firms.

Using unit values to make inferences about the role of product quality in determining export patterns can be misleading because many factors other than quality affect prices. For instance, holding quality fixed, more efficient firms may find it optimal to charge lower prices for their products. Instead, recent papers obtain a proxy for product quality from demand residuals. Because consumers decide how much to purchase of each good by comparing quality-adjusted prices, two firms that charge the same price but have different market shares must sell varieties of different quality. In particular, firms that sell large quantities of physical output conditional on price are classified as high quality producers. Khandelwal (2011) applies this method to estimate quality for a broad sample of countries using aggregate trade data. He finds that markets characterized by relatively small scope for quality differentiation are associated with larger employment and output declines resulting from low-wage competition. Similarly, Hallak & Schott (2011) estimate quality for a panel of 43 countries between 1989 and 2003. They find that export quality is correlated with the exporter's income per capita, but they also find that during this period quality levels are converging whereas income per capita is not. Finally, Gervais (2011) uses US Census data to estimate quality at the plant-level and decomposes cross-plant variation in price and export status into quality and efficiency margins. Prices are found to be increasing in quality and decreasing in efficiency, but, selection into exporting is driven mainly by quality.

8 Intermediaries

While in many models of international trade consumers purchase imports directly from foreign producers, the prevalence of firm importing has stimulated recent research on the role of intermediaries, such as wholesalers and retailers, in the process of international trade. Bernard et al. (2010c) examine the differences between wholesalers, retailers and other categories of U.S. trading firms using data from the U.S. Linked/Longitudinal Firm Trade Transaction Database (LFTTD).[15] While wholesale firms comprise 35 percent of exporters and

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[15]As in most international trade datasets, firms that trade directly in LFTTD cannot be compared to those that trade indirectly via wholesalers or retailers, since the latter's sales or purchases within the U.S. are not observed.

42 percent of importers, they account for only 8 percent of export value and 15 percent of import value. Retailers are less prevalent and smaller than wholesalers, accounting for 9 percent of exporters and 13 percent of importers but only 1 percent of export and import value. In contrast, firms with operations that span wholesale or retail and other sectors (typically large firms) comprise around only 5 percent of exporters and importers, but account for more than 60 percent of export value and more than 50 percent of import value. Therefore the vast majority of trade is undertaken by a relatively small number of large traders that vertically integrate wholesale/retail activities within firm boundaries. Using Italian trade transaction data, Bernard et al. (2010d) find that the share of exports mediated by wholesalers is positively correlated with proxies for country-specific fixed costs, including the World Bank's Doing Business measures of the number of documents for importing, cost of importing and time to import.

Using Chinese trade transaction data, Ahn et al. (2011) consider a different definition of intermediaries based on firms having the English-equivalent meaning of "importer," "exporter," and/or "trading" in their name. Such intermediary firms account for around $168 billion of China's exports or around 22 percent of the total. The paper develops a model in which intermediaries are used by relatively small firms that do not find it profitable to incur the fixed costs of directly exporting to foreign markets by themselves.[16] Consistent with intermediaries handling the products of other firms, they export relatively more products per destination market than other trading firms. In line with the idea that the fixed costs of direct exporting are more likely to be prohibitive in a small and remote foreign markets, intermediaries account for larger export shares in smaller markets and markets with higher trade costs.

Blum et al. (2011) provide further indirect evidence on intermediation using matched importer-exporter transaction data for Chile and Colombia. Consistent with the concentration of U.S. trade discussed above, the distributions of bilateral exports and imports between Chile and Columbia are highly skewed across firms. More than half of exporters sell to only one importer, whereas the 99th percentile exporter sells to 19 importers. Similarly, more than half of importers deal with only one exporter, whereas the 99th percentile importers deals with 9 exporters. More generally, while one party to a transaction can be small and engage with few other traders, the other party to the transaction is typically large and deals with many other traders. This pattern of results is consistent with the idea that efficient trades involve large trade volumes, which can be achieved either by small importers matching with large exporters or small exporters matching with large importers. Motivated by these findings, the paper develops a theoretical model in which firms choose whether to access markets directly or indirectly via intermediaries. Since the direct exporting technology is characterized by increasing returns to scale, it is used by large exporters selling directly to many importers. In contrast, the intermediation technology is employed by large importers that spread the costs of intermediation over many small exporters.

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[16] Other models of intermediation with similar patterns of selection of firms into intermediation and direct exporting include Akerman (2010) and Felbermayr & Jung (2008).

More broadly, a key challenge in international trade is opening the black box of trade costs. Theories of heterogeneous firms and international trade posit the existence of fixed and variable trade cost parameters, but there is still little understanding of what these parameters capture. The literature on intermediaries in international trade takes some first steps towards understanding the chains of decisions involved in conducting goods from production to final consumption. Recent empirical research suggests that these trade and distribution networks may be important for a variety of issues in international trade, such as the border effect, exchange rate pass-through and the relationship between nominal and real exchange rates, as in Burstein et al. (2005) and Li et al. (2011). Other micro evidence on the potential importance of firm distribution networks comes from empirical findings of "Carry-Along Trade (CAT)" in Bernard et al. (2010e), where more than three quarters of the exported products and more than one quarter of export value from Belgian manufacturers are in goods that are not produced by firms. Recent theoretical research on search, networks and intermediation in international trade (e.g. Rauch & Trinidade 2003, Petropoulou 2007, Antràs & Costinot 2011) provides further guidance for future empirical work.

9 Foreign Direct Investment

Multinational firms play a central role in the global economy, with U.S.-based multinationals mediating more than 90 percent of U.S. trade in Bernard et al. (2009a). Indeed, for countries whose firms have large networks of overseas subsidiaries, the sales of these subsidiaries can dwarf international trade flows.

While Melitz (2003) focuses on exports, Helpman et al. (2004) generalize the analysis to incorporate horizontal foreign direct investment (FDI), allowing firms to choose between incurring a fixed cost of exporting or a fixed cost of establishing an overseas affiliate. If the fixed costs of FDI are sufficiently high relative to the fixed costs of exporting, the most productive firms serve the foreign market through FDI; firms with an intermediate range of productivities export; firms with a lower range of productivities only serve the domestic market. With a Pareto productivity distribution, the importance of FDI relative to exporting as a mode for serving the foreign market is decreasing in the shape parameter of the Pareto productivity distribution (increasing in firm productivity dispersion). Consistent with this prediction, Helpman et al. (2004) show that the share of total foreign market sales accounted for by the sales of foreign affiliates is larger in industries with smaller estimated shape parameters for the distribution of firm sales (which in the model is directly related to the distribution of firm productivity).

Using Bureau of Economic Analysis (BEA) microdata on U.S. firms and their overseas affiliates, Yeaple (2009) provides further evidence in support of theories of heterogeneous firms and FDI. Consistent with firm selection, more productive U.S. firms own affiliates in a larger number of countries and these affiliates generate greater revenue from sales in their host countries. Consistent with country selection, as a country becomes more attractive to U.S. multinationals, it attracts progressively smaller and less productive firms. While the

model accounts for many features of the data, there are others that are less well explained. The dispersion in the number of foreign countries entered is smaller than predicted by the model given the observed dispersion in U.S. market shares: large firms invest in too few foreign locations and small firms invest in too many, with the largest firms underrepresented among the least attractive locations.

Using Norwegian data, Irarrazabal et al. (2010) show that patterns of multinational activity by firm and destination market exhibit a number of similarities with the patterns of trade by firm and destination market in Eaton et al. (2011a). In particular, while total affiliate sales and the number of foreign affiliates are less sensitive to distance than exports, they both decline with distance. This gravity-equation relationship is inconsistent with a simple model of horizontal FDI, in which FDI should become more attractive as a mode for serving the foreign market as trade costs increase.[17] To explain these findings, Irarrazabal et al. (2010) extend the model of firm heterogeneity and FDI of Helpman et al. (2004) to incorporate traded intermediate inputs and find empirical support for the extended model. To analyze the joint determination of patterns of trade and FDI, Ramondo and Rodriguez-Clare (2010) develop an extension of Eaton and Kortum (2002) that incorporates both of these modes of serving foreign markets. Within this framework, the welfare gains from trade can be more than twice as large as in a model with only trade, while the gains from multinational production are slightly lower than in a model with only multinational production.

10   Intra-Firm Trade

Multinational firms not only dominate international trade flows but also undertake a substantial proportion of their trade within the boundaries of the firm. Such trade between related parties accounts for around one half of U.S. imports.[18] While many of the models of FDI discussed above assume that overseas production is organized within the boundaries of the firm, more recent research has sought to explicitly model this choice of firm organization. When overseas production is organized within the boundaries of the firm, foreign affiliates may either specialize in different stages of production from the parent firm (vertical FDI) or may undertake the same production activities in a different location (horizontal FDI). To the extent that stages of production are traded across national borders, vertical FDI involves intra-firm trade.

As well as dominating U.S. imports, intra-firm trade is concentrated in capital-intensive industries and between capital-abundant countries. To explain these features of the data, Antràs (2003) models a final goods producer who decides whether to outsource foreign production of an intermediate input to a standalone supplier or to engage in foreign direct investment (FDI) in which case the overseas production of the intermediate input is vertically integrated within the firm. The final goods producer and the intermediate

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[17]In principle, the gravity equation relationship for affiliate sales and the number of affiliates can be reconciled with a model of horizontal FDI if there there are costs of operating foreign affiliates that increase with distance. See, for example, Keller & Yeaple (2011) and Arkolakis et al. (2011b).

[18]U.S. import partners are defined as being "related" if either party owns, directly or indirectly, 6 percent or more of the other party.

input supplier make relationship-specific investments in capital and labor respectively. Contracts are incomplete because neither the quality of the intermediate input nor the amount of investments in capital and labor can be verified by a third party and contracts cannot be written on sales revenues. The only contractibles are therefore the allocation of residual rights of control and an *ex ante* transfer between the final goods supplier and intermediate input producer. Since the final goods producer's investment in capital is relatively more important in a capital-intensive industry, vertical integration is more likely in the capital-intensive industry, matching the empirical findings for U.S. imports discussed above. Furthermore, the model is also consistent with the empirical finding of a higher share of intra-firm trade in U.S. imports from capital-abundant countries, because there is greater intra-industry trade in the capital-intensive industry with these countries.

Antràs & Helpman (2004) augment this analysis to incorporate firm heterogeneity. Since the fixed costs of producing abroad are lower when outsourcing to a foreign supplier than when using foreign direct investment, only the most productive firms can generate sufficient variable profits to offset the large fixed costs of vertical integration. As a result, the share of U.S. imports that are intra-firm is predicted to increase not only in the share of relationship-specific investments undertaken by the headquarters firm but also in the dispersion of firm productivity. To examine these predictions, Nunn & Trefler (2008) use U.S. data on related-party and arms-length trade by disaggregated HS 6-digit product and on capital and skill-intensity for more aggregated industries. Consistent with the predictions of the model, the share of intra-firm trade in U.S. imports is increasing in industry capital and skill-intensity (as proxies for the importance of headquarters investments), in the dispersion of U.S. exports within each 6-digit product (as a proxy for the dispersion of productivity), and in interactions between these two variables.

Antràs & Helpman (2008) generalize the theoretical analysis to allow inputs to be partially contractible. In this framework, an improvement in foreign property rights has two offsetting effects on the share of intra-firm trade through the two productivity cutoffs which separate domestic production (low productivity), foreign outsourcing (intermediate productivity) and foreign vertical integration (high productivity). On the one hand, an improvement in foreign property rights reduces the productivity cutoff for outsourcing, as some inputs that were previously produced domestically are now outsourced abroad, which reduces the share of intra-firm trade. On the other hand, as foreign property rights improve, the intermediate input supplier's share of non-contractible inputs falls, which implies that the party whose investments require relatively more incentives is the headquarters firm. As a result, the productivity cutoff for vertical integration falls, as some inputs that were previously outsourced abroad are now vertically integrated abroad, which increases the share of intra-firm trade. For a range of parameter values, the second effect can dominate, which yields the surprising prediction that an improvement in foreign property rights can *increase* the extent of vertical integration. Consistent with this prediction, Nunn & Trefler (2008) find that the share of intra-firm trade is positively related to interactions between capital and skill-intensity (as proxies for the importance of

headquarters investments) and an empirical measure of the "rule of law" (as a proxy for the quality of foreign property rights).[19]

Additional empirical support for the above theoretical predictions is provided by Yeaple (2006), which uses Bureau of Economic Analysis (BEA) data on the value of imports by U.S. parent firms from their foreign affiliates as a measure of intra-firm trade. Consistent with the theoretical predictions of Antràs & Helpman (2004), the share of intra-firm trade in U.S. imports is increasing in both industry capital-intensity and research and development (R&D) intensity (as proxies for the importance of headquarters investments) and the dispersion of sales across establishments within industries (as a proxy for the dispersion of productivity). These estimated effects vary with U.S. trade partners' levels of development, with the largest and most precisely estimated coefficients found for the least-developed and newly-developing countries.[20]

To further examine the determinants of intra-firm trade, Bernard et al. (2010b) use the trade-transaction and establishment-employment data in LFTTD to construct a new measure of products' "revealed contractibility," which is based on the idea that contracting is likely to be easier for products passing through intermediaries such as wholesalers. Intra-firm trade exhibits a non-linear relationship with country and industry characteristics. On the one hand, higher quality property rights are associated with a higher probability of related-party trade taking place. On the other hand, conditional on positive related-party trade occurring, higher quality property rights are correlated with a lower share of related-party trade, which is consistent with the idea that higher quality property rights facilitate arms-length transactions.

11 Labor Markets

A key implication of the Melitz (2003) model is that firms are unevenly affected by trade liberalization: low-productivity firms exit, intermediate-productivity domestic firms contract, and high-productivity exporting firms expand. In contrast, workers are symmetrically affected by trade liberalization, since workers are identical and the labor market is frictionless, so that all workers are employed for a common wage. These labor market implications sit awkwardly with the large empirical literature on the employer-size wage premium (see, for example, the survey by Oi & Idson 1999) and empirical findings of wage differences between exporters and non-exporters even after controlling for firm size (see, in particular, Bernard & Jensen 1995, 1997).

More recently, the theoretical literature on heterogeneous firms and trade has highlighted two sets of reasons why wages can vary with revenue across firms. One line of research assumes competitive labor markets, so that all workers with the same characteristics are paid the same wage, but wages vary across firms as a result of differences in workforce composition (see for example Bustos 2007, Verhoogen 2008 and

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[19]For more general evidence on the role of property rights in determining the pattern of trade, see Nunn (2007).

[20]Corcos et al. (2010) and Defever & Toubal (2010) examine the determinants of intra-firm trade using French trade transaction data. While Defever & Toubal (2010) explore the implications of different assumptions about the relative magnitude of the fixed costs of outsourcing and vertical integration, Corcos et al. (2010) emphasize the distinction between the extensive and intensive margins. See Kohler & Smolka (2011) for evidence using Spanish data.

Yeaple 2005). Another line of research introduces labor market frictions, so that workers with the same characteristics can be paid different wages by different firms. One source of labor market imperfections is search and matching frictions, where bargaining over the surplus from production can potentially induce wages to vary with revenue across firms (see for example Davidson et al. 2008, Cosar et al. 2011, and Helpman et al. 2010). Another source of labor market imperfections is efficiency or fair wages, where the wage that induces effort or is perceived to be fair varies with revenue across firms (see for example Amiti & Davis 2011, Davis & Harrigan 2011, and Egger & Kreickemeier 2009).

This class of theoretical models highlights a new mechanism for trade to affect wage inequality based on wage variation across firms and the selection of firms into international markets.[21] Helpman et al. (2011) provide evidence on the quantitative importance of this new mechanism for understanding the relationship between wage inequality and trade using Brazilian employer-employee and trade transaction data. Consistent with the class of theoretical models discussed above, wage inequality between firms within sector-occupations accounts for a substantial proportion of the level and growth of overall wage inequality, and this between-firm wage inequality remains important after controlling for observable worker characteristics. To the extent that existing empirical studies inspired by neoclassical trade theory focus on changes in relative wages between different sectors and types of workers, they abstract from an important channel through which trade liberalization can affect wage inequality.

A number of recent empirical studies have used matched employer-employee data to try to determine whether wage differences between exporters and non-exporters (as found by Bernard & Jensen 1995, 1997) are the result of differences in the composition of workers across firms or wage premia for workers with the same characteristics. Following Abowd et al. (1999, 2001), this literature typically estimates worker and firm fixed effects under the strong identifying assumptions that switches of workers between firms are random conditional on the covariates and that each worker's wage is a log linear function of their ability and does not depend directly on the ability of their co-workers. Empirical studies within this literature generally find contributions from both differences in workforce composition and wage premia, with the relative magnitude of these contributions varying across studies. Using Mexican data, Frías et al. (2009) find that approximately two-thirds of the higher level of wages in larger, more productive plants is explained by higher levels of wage premia and that nearly all of the differential changes in wages across plants as a result of the shock of the peso devaluation are explained by changes in wage premia. Using German data, Schank et al. (2007) find that wage differences between exporters and non-exporters become smaller but do not completely vanish once observable and unobservable characteristics of workers are controlled for. For other evidence using Brazilian and Swedish employer-employee data, see Krishna et al. (2010) and Davidson et al. (2010) respectively.

Amiti & Davis (2011) examine the separate impacts of input and output tariffs on firm wages. Extending

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[21]In the presence of labor market frictions, trade may also affect income inequality through changes in unemployment, as in Felbermayr et al. (2011) and Helpman & Itskhoki (2010).

the Melitz (2003) model to incorporate firm importing, they show that a fall in output tariffs lowers wages at import-competing firms, but boosts wages at exporting firms. Additionally, a fall in input tariffs raises wages at import-using firms relative to those at firms that only source inputs locally. Using Indonesian firm-level census of manufactures data, they find strong empirical support for both predictions.[22]

In parallel to this research on labor market frictions, another line of related work has considered capital market imperfections. Manova (2011) develops a heterogeneous-firm model, in which countries vary in financial development and sectors differ in financial vulnerability, and provides empirical evidence on the model's predictions. Using disaggregated trade data by country and product, more financially-advanced countries are found to be more likely to enter any given destination market and to export more conditional on trading. These effects are statistically significantly stronger in sectors with greater requirements for outside finance or with fewer collateralizable assets.

12 Firm Export Market Dynamics

Much of the theoretical and empirical literature on heterogeneous firms and trade focuses on the cross-section distribution of trade across firms, products and countries. More recent research has begun to explore the dynamics of firms' decisions to enter export markets and its implications for the impact of trade liberalization.

Using transaction-level customs data for Colombia for the period 1996-2005, Eaton et al. (2008) establish a number of key features of firm export dynamics. In a typical year, nearly one half of all Colombian exporters were not exporters in the previous year. These new exporters are small as a share of total exports and most do not continue exporting in the following year. Total exports are instead dominated by a small number of large and stable exporters. Nonetheless, out of each cohort of new exporters, a fraction of firms go on to rapidly expand exports, and over a period of less than one decade, these successful new exporters account for almost half of total export growth. Firms typically begin exporting in a single foreign market and, if they survive, gradually expand into additional destinations. The geographic pattern of their expansion paths, and their likelihood of survival as exporters, depend on their initial destination market.

One line of research has sought to explain these export dynamics in terms of learning, as in Eaton et al. (2011c), Akhmetova (2011), Albornoz et al. (2011) and Segura-Cayuela and Vilarrubia (2008). According to this view, firms update their priors about profitability in export markets based upon their sales, and hence either exit or expand their penetration of export markets over time. Albornoz et al. (2011) consider a setting in which export market profitability is uncertain but correlated across export markets. As a result, a firm may enter an export market even if the expected profits from entering that market alone are negative, because of the option value of expanding to additional export markets if successful. An implication of this

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[22] For evidence on the relationship between the firm skill premium and input and output tariffs, see Amiti and Cameron (2011).

framework is that firm export market growth should be particularly rapid in the first year of exporting, which receives empirical support in Argentinian trade transaction data.[23]

Another line of research tries to explain these export dynamics through stochastic shocks to productivity, as in Arkolakis (2011) and Ruhl and Willis (2011). As productivity evolves over time, firms decide whether to enter or exit individual export markets and whether or not to continue production. In Arkolakis (2011), these stochastic shocks to productivity are combined with a model of endogenous market penetration. A firm enters a market if it is profitable to incur the marginal cost to reach the first consumer and pays an increasing market penetration cost to reach additional consumers. The model is calibrated using data on the cross-section of firms and their sales across markets as well as the rate of incumbent firm exit. The calibrated model is shown to be quantitatively successful in predicting firm exit, growth, and the resulting firm-size distribution in U.S. manufacturing data.

Bernard et al. (2009b) use U.S. transaction-level data to compare the role of the extensive and intensive margins in accounting for cross-section and time-series patterns of trade. The extensive margins of the number of firms and products explain the majority of the variation in trade flows across countries. In contrast, year-on-year changes in trade are driven by the intensive margin of trade within continuing firm-product-country trade relationships. One reason for the relative small contributions of the extensive margins over short time intervals is that entering and exiting exporters, as well as recently added and about-to-be-dropped firm-product-country trade relationships, are on average relatively small compared to continuing firm-product-country trade relationships. Conversely, conditional on survival, entering exporters and recently added firm-product-country trade relationships grow more rapidly than incumbent exporters and continuing firm-product-country trade relationships. Analysis of the Asian crisis in the late 1990s confirms these time-series results: while there are substantial changes in the extensive margin of the number of exporters, the majority of the change in the dollar value of trade around the Asian crisis is driven by the intensive margin. Notably, the extensive and intensive margins behave differently for arms-length and related-party trade, suggesting that the global production networks of multinational corporations play a role in influencing the response of the macroeconomy to shocks.

13   Conclusion

Empirical findings from microdata on plants and firms have presented challenges to traditional theories of international trade and stimulated the development of recent models of heterogeneous firms and trade. These recent theories explain empirical findings that only some firms export, exporters are larger and more

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[23]In the presence of learning and imperfect contract enforcement, Araujo et al. (2011) argue that institutions may affect export dynamics. Other things equal, exporters have higher initial exports and remain as exporters for longer in countries with better contracting institutions. However, conditional on survival, the growth rate of a firm's exports to a country decreases with the quality of the country's institutions.

productive than non-exporters, and trade liberalization raises average productivity through reallocations of resources across firms within industries.

These new theories highlight additional mechanisms through which the aggregate economy is affected by the opening of trade and have stimulated further empirical research exploring these mechanisms. Aggregate economic relationships such as the gravity equation are largely driven by the extensive margins of firms and products rather than the intensive margin of average exports per firm-product. Reductions in trade costs induce endogenous changes in internal firm organization as firms adjust their range of products, their decisions about whether to serve foreign markets through trade or overseas production, and their choices about whether to organize foreign production within or beyond the boundaries of the firm. To the extent that wages vary with firm revenue and only some firms export, firm heterogeneity provides a new mechanism for trade to affect wage inequality.

While early empirical studies examined export behavior using plant or firm-level data, the more recent availability of customs data on individual trade transactions has enhanced our ability to look inside the black box of the firm and led to an explosion of research across a broad range of areas. These include multi-product firms, intra-firm trade, intermediation, and the dynamics of firm entry into export markets. There remain many fundamental issues ahead, such as the microfoundations of trade costs, further exploration of the boundaries of the firm, and further consideration of the relationship between findings from disaggregated data and the economy's aggregate response to trade.

Acknowledgements

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Table 1: Exporting by U.S. Manufacturing Firms, 2002

NAICS Industry		Percent of Firms	Percent of Firms that Export	Mean Exports as a Percent of Total Shipments
311	Food Manufacturing	6.8	11.6	14.8
312	Beverage and Tobacco Product	0.7	22.9	7.4
313	Textile Mills	1.0	25.1	12.5
314	Textile Product Mills	1.9	12.2	11.7
315	Apparel Manufacturing	3.2	7.7	13.5
316	Leather and Allied Product	0.4	24.4	13.4
321	Wood Product Manufacturing	5.5	8.5	18.5
322	Paper Manufacturing	1.4	23.8	9.0
323	Printing and Related Support	11.9	5.5	14.4
324	Petroleum and Coal Products	0.4	17.8	11.5
325	Chemical Manufacturing	3.1	36.1	14.3
326	Plastics and Rubber Products	4.4	28.1	10.3
327	Nonmetallic Mineral Product	4.0	9.5	12.1
331	Primary Metal Manufacturing	1.5	30.2	10.4
332	Fabricated Metal Product	19.9	14.3	11.6
333	Machinery Manufacturing	9.0	33.0	15.5
334	Computer and Electronic Product	4.5	38.3	21.3
335	Electrical Equipment, Appliance,	1.7	37.7	12.9
336	Transportation Equipment	3.4	28.0	13.0
337	Furniture and Related Product	6.4	6.5	10.1
339	Miscellaneous Manufacturing	9.1	1.6	14.9
Aggregate Manufacturing		100.0	17.6	14.1

Source: Bernard et al. (2007).

Notes: Data are from the 2002 U.S. Census of Manufactures. Column 2 summarizes the distribution of manufacturing firms across three-digit NAICS manufacturing industries. Column 3 reports the share of firms in each industry that export. The final column reports mean exports as a percent of total shipments across all firms that export in the noted industry.

Table 2: Exporter Premia in U.S. Manufacturing

	(1)	(2)	(3)
Log Employment	1.19	0.97	.
Log Shipments	1.48	1.08	0.08
Log Value Added per Worker	0.26	0.11	0.10
Log TFP	0.02	0.03	0.05
Log Wage	0.17	0.06	0.06
Log Capital per Worker	0.32	0.12	0.04
Log Skill per Worker	0.19	0.11	0.19
Additional Covariates	None	Industry Fixed Effects	Industry Fixed Effects, Log Employment

Source: Bernard et al. (2007).

Notes: Data are for 2002 and are from the U.S. Census of Manufactures. All results are from bivariate OLS regressions of firm characteristic in first column on a dummy variable indicating firm's export status. Columns two and three include industry fixed effects and industry fixed effects plus log firm employment, respectively, as additional controls. Total factor productivity (TFP) is computed as in Caves et al (1982). Capital and skill per worker are capital stock and non-production workers per total employment, respectively. All results are significant at the 1 percent level.

Table 3: Distribution of Exporters and Export Value by Number of Products and Export Destinations, 2000

A. Share of Exporting Firms

Number of Products	Number of Countries					
	1	2	3	4	5+	All
1	40.4	1.2	0.3	0.1	0.2	42.2
2	10.4	4.7	0.8	0.3	0.4	16.4
3	4.7	2.3	1.3	0.4	0.5	9.3
4	2.5	1.3	1.0	0.6	0.7	6.2
5+	6.0	3.0	2.7	2.3	11.9	25.9
All	64.0	12.6	6.1	3.6	13.7	100.0

B. Share of Export Value

Number of Products	Number of Countries					
	1	2	3	4	5+	All
1	0.2	0.1	0.0	0.0	0.1	0.4
2	0.2	0.1	0.0	0.0	0.1	0.5
3	0.2	0.1	0.0	0.0	0.2	0.5
4	0.1	0.1	0.1	0.0	0.3	0.6
5+	2.6	1.2	1.0	0.9	92.2	98.0
All	3.3	1.5	1.2	1.0	92.9	100.0

C. Share of Employment

Number of Products	Number of Countries					
	1	2	3	4	5+	All
1	7.0	0.0	0.0	0.0	0.0	7.1
2	1.9	2.6	0.1	0.0	0.0	4.6
3	1.3	1.0	0.8	0.0	0.2	3.3
4	0.5	0.4	0.3	0.2	0.2	1.6
5+	3.5	2.6	4.3	4.1	68.8	83.3
All	14.2	6.7	5.5	4.3	69.2	100.0

Source: Bernard et al. (2007).

Notes: Data are from the 2000 LFTTD. Table displays the joint distribution of U.S. manufacturing firms that export (top panel), their export value (middle panel) and their employment (bottom panel), according to the number of products firms export (rows) and their number of export destinations (columns). Products are defined as ten-digit Harmonized System categories.

Table 4: Gravity the Margins of Trade

	ln(Value$_c$)	ln(Avg Exports$_c$)	ln(Obs$_c$)	ln(Firms$_c$)	ln(Products$_c$)	ln(Density$_c$)
ln(Distance$_c$)	-1.37	0.05	-1.43	-1.17	-1.1	0.84
	0.17	0.1	0.17	0.15	0.15	0.13
ln(GDP$_c$)	1.01	0.23	0.78	0.71	0.55	-0.48
	0.04	0.02	0.04	0.03	0.03	0.03
Constant	7.82	6.03	1.8	0.52	3.48	-2.2
	1.83	1.07	1.81	1.59	1.55	1.37
Observations	175	175	175	175	175	175
Fixed Effects	No	No	No	No	No	No
R^2	0.82	0.37	0.75	0.76	0.68	0.66

Source: Bernard et al. (2011).

Notes: Table reports results of OLS regressions of U.S. export value or its components on trading-partners' GDP and great-circle distance (in kilometers) from the United States. All five columns are country-level regressions. Heteroscedasticity robust standard errors are noted below each coeficient. Data are for 2002.

Table 5: Trading Premia in U.S. Manufacturing, 1997

	Exporter Premia	Importer Premia	Exporter & Importer Premia
Log Employment	1.50	1.40	1.75
Log Shipments	0.29	0.26	0.31
Log Value Added per Worker	0.23	0.23	0.25
Log TFP	0.07	0.12	0.07
Log Wage	0.29	0.23	0.33
Log Capital per Worker	0.17	0.13	0.20
Log Skill per Worker	0.04	0.06	0.03

Source: Bernard et al. (2007)

Notes: Data are for 1997 and are for firms that appear in both the U.S. Census of Manufacturers and the LFTTD. All results are from bivariate OLS regressions of firm characteristic in first column on dummy variable noted at the top of each column as well as industry fixed effects and firm employment as additional controls. Employment regressions omit firm employment as a covariate. Total factor productivity (TFP) is computed as in Caves et al (1982). Capital and skill per worker are capital stock and non-production workers per total employment, respectively. All results are significant at the 1 percent level.