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DP16249

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INTERNATIONAL TRADE AND REGIONAL ECONOMICS

CEPR

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Discussion Paper DP16249

Published 12 June 2021

Submitted 11 June 2021

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www.cepr.org

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Abstract

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JEL Classification: E23, F12, F14, L11, R12

Keywords: Firm Heterogeneity, Top Firms, selection, reallocation, margins of trade

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International Trade with Heterogeneous Firms: Theory and Evidence*

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Abstract

International trade is dominated by a small number of very large firms. Models of trade with heterogeneous firms have been developed to study the causes and consequences of this observation. The canonical model of trade with heterogeneous firms shows that trade leads to between-firm reallocations and selection: it shifts employment towards firms with the best attributes and forces marginal firms to exit. The model also illustrates the role of heterogeneity, and its various sources, in explaining the volume of trade and the firm-level margins of adjustment. Consistent with the model, earlier empirical studies have documented that exporting is a rare activity, that exporting firms are larger and more productive than other firms, and that trade liberalization reallocates market shares towards the best-performing firms in various countries. More recent studies using transaction-level data have unveiled additional salient features of trade flows. First, sales by foreign firms are very heterogeneous and highly concentrated. Second, both the extensive margin (number of exporting firms) and the intensive margin (average export per firm) are important in explaining the level of exports and its changes over time. More heterogeneity in sales across firms is associated with a higher volume of trade along both margins. Third, increased foreign competition reallocates market shares towards top firms and hence can increase concentration from any country of origin. Numerous extensions of the benchmark model have been proposed to study other important aspects, such as the relevance of multi-product and multinational firms and the extent to which heterogeneity is endogenous to firms' choices, but some open challenges still remain.

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*Draft prepared for the Oxford Research Encyclopedia of Economics and Finance (<https://oxfordre.com/economics>).

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1 INTRODUCTION

International trade is dominated by few large corporations. Bernard et al. (2018) show that the top 1% of firms account for more than 80% of US trade. Freund and Pierola (2015) find that the top-5 firms control on average 30% of total exports in a sample of 32 mostly developing countries. Gaubert and Itskhoki (2021) report that the largest firm in France accounts for 7% of all French manufacturing exports and that, within narrowly defined industries, the top exporter accounts on average for 28% of exports. Despite these striking observations on the extreme concentration of trade flows, differences in size across firms have been introduced only recently into trade models. This article reviews the state of the literature on this topic, its main theoretical insights and empirical findings.

Ever since the works of Ricardo (1817) and Heckscher and Ohlin (1933), traditional models have focused on inter-sectoral trade. Yet, when product-level data became available, it soon became apparent that most of trade involves two-way flows of similar products within industries (Grubel and Lloyd, 1975). During the 1980s, new models were developed to explain this phenomenon. Their hallmarks were imperfect competition, increasing returns and a novel attention on firms. The change in perspective was so radical to deserve the name of "new" trade theory. Yet, these models focused on homogenous firms, not because economists were unaware of the stark asymmetries that characterize any industrial sector, but because these were considered unimportant for the aggregate implications.

In the late 1990s, once firm-level data became available, a new set of stylized facts emerged. In any country and sector, researchers found that only a minority of firms engage in export activities, and those that do are systematically larger and more productive than other firms (Bernard and Jensen, 1995). Moreover, trade is associated with reallocations across firms: as exporters expand their sales in foreign markets, other firms must scale down their business. And these reallocations are an important determinant of aggregate productivity (Bernard and Jensen, 1999). These stylized facts demonstrated that firm heterogeneity is central to the understanding of the causes and consequences of international trade, and motivated the effort to incorporate it into existing models.

This article provides a selective overview of the literature that followed. It starts by presenting the canonical model of trade with heterogeneous firms based on Melitz (2003). The key assumptions are that firms pay an entry cost to draw their attributes randomly, and that there are fixed costs of selling into different markets. As a result, firms with different size coexist in equilibrium, and only the firms with better attributes find it profitable to pay the higher costs of entering foreign markets. The most distinctive result of this class of models is that trade leads to between-firm reallocations and selection: more export opportunities and tougher competition shift employment in favor of the firms with the best attributes and can force marginal firms to exit. The model also clarifies the role of heterogeneity, and its various

sources, in explaining the volume of trade and the firm-level margins of adjustment.

The second section of the article surveys the empirical works testing these theoretical predictions. After reviewing the initial observations that started this line of research, the section uses transaction-level data on US imports to summarize some of the most recent empirical findings in the literature. First, it shows how heterogeneity in US sales by foreign firms varies across manufacturing industries, and quantifies the importance of top firms. Second, the section discusses firm-level decompositions measuring the importance of the extensive margin (number of exporting firms) and the intensive margin (average export per firm) in explaining the level and changes in the volume of US imports. To illustrate the role of firm heterogeneity, it then investigates the relationship between each margin and a measure of dispersion in sales. Finally, the section considers the evidence on how foreign competition reallocates market shares towards top firms and can thereby be followed by an increase in industry concentration.

The last section reviews some of the most important extensions of the benchmark theoretical framework and some open challenges. Among these, it discusses models of multi-product firms, in which selection operates also within firms, models of multinational firms, in which heterogeneity in attributes maps into alternative modes of organization, and models in which the extent of heterogeneity is endogenous to firms' choices.

2 TRADE WITH HETEROGENEOUS FIRMS: THEORY

This section describes the workhorse model of trade with heterogeneous firms. The model was first developed in Melitz (2003), but the exposition here is closer to the multi-sector and multi-country synthesis in Melitz and Redding (2014) and Bernard et al. (2018). It builds on the model of trade with monopolistic competition in Krugman (1980). The key innovation is that firms, after paying an entry cost, draw their attributes, in this version quality and efficiency, from some known distribution. This introduces asymmetries between firms. Moreover, to sell in each destination, firms must incur both a fixed cost and a variable trade cost. Labor is the only factor of production.

2.1 THE BENCHMARK MODEL

In any destination d , preferences over consumption of goods produced in I industries are:

$$U_d = \sum_{i=1}^I \beta_i \ln C_{di}, \quad \beta_i > 0, \quad \sum_{i=1}^I \beta_i = 1. \quad (1)$$

This implies that expenditure allocated to each industry, E_{di} , is a constant fraction β_i of income. Industries $i \in \{1, \dots, I\}$ comprises differentiated varieties and consumers have Constant Elasticity of Substitution (CES) preferences over these varieties:

$$C_{di} = \left\{ \int_{\omega \in \Omega_{di}} [\gamma(\omega) c_d(\omega)]^{\frac{\sigma_i-1}{\sigma_i}} d\omega \right\}^{\frac{\sigma_i}{\sigma_i-1}}, \quad \sigma_i > 1, \quad (2)$$

where $c_d(\omega)$ is quantity consumed of variety ω , $\gamma(\omega)$ is a demand shifter, Ω_{di} denotes the set of varieties available for consumption in market d in industry i , and σ_i is the elasticity of substitution between these varieties. The demand shifter $\gamma(\omega)$ can be interpreted as "quality", in that it measures the value of a product for a given quantity consumed. It is assumed to be an intrinsic attribute of the variety, although it could also be destination specific.

Denote by $p_d(\omega)$ the price of variety ω in destination d and by P_{di} the minimum cost of one unit of the consumption basket C_{di} :

$$P_{di} = \left\{ \int_{\omega \in \Omega_{di}} \left[\frac{p_d(\omega)}{\gamma(\omega)} \right]^{1-\sigma_i} d\omega \right\}^{\frac{1}{1-\sigma_i}}. \quad (3)$$

The price index P_{di} , which is an inverse measure of competition in a market, is decreasing in the number of varieties and increasing in their price. Demand for variety ω is:

$$c_d(\omega) = p_d(\omega)^{-\sigma_i} \gamma(\omega)^{\sigma_i-1} P_{di}^{\sigma_i-1} E_{di}, \quad (4)$$

which is a negative function of the price, with elasticity σ_i , and a positive function of quality.

In the benchmark model, market structure is monopolistic competition. Specifically, each variety ω in any industry is produced by a single firm which, being infinitesimal, takes wages and price indexes as given.¹ Varieties, i.e. firms, can be created after paying a fixed cost and entry continues as long as it is profitable. Upon entry, each firm draws randomly labor productivity, φ , and quality, γ , from a known distribution. As a result, in equilibrium firms with different attributes coexist.

The problem of the firm is solved backward: the behavior of existing firms is studied first, and the entry decision next. Since all firms with the same attributes (φ, γ) behave similarly, firms can be indexed by the pair (φ, γ) . Given demand (4), the profit-maximizing price of a firm with attributes (φ, γ) serving market d from country o is:

$$p_{doi}(\varphi, \gamma) = \frac{\sigma_i}{\sigma_i - 1} \frac{\tau_{doi} w_o}{\varphi}, \quad (5)$$

¹This assumption is relaxed in Section 2.4.

where w_o is the wage in country o , $\tau_{doi} \geq 1$ is the variable (iceberg) cost of shipping from o to d in industry i and $\sigma_i/(\sigma_i - 1)$ is the markup over the marginal cost charged by the firm. There is no variable trade cost when selling to the domestic market, i.e., $\tau_{ooi} = 1$.

Equations (4) and (5) imply that revenue in market d is an increasing function of a synthetic measure of overall "appeal" of the firm, $\phi \equiv \varphi\gamma$:

$$r_{doi}(\phi) = E_{di} \left(P_{di} \frac{\sigma_i - 1}{\sigma_i} \frac{\phi}{\tau_{doi} w_o} \right)^{\sigma_i - 1}. \quad (6)$$

In order to sell to destination d firms must pay a fixed cost of f_{doi} units of labor. It includes all costs related to the acquisition of information about demand, marketing, distribution and compliance with regulations, that do not depend on the volume of sales.² Without these costs, firms would sell to all destinations, irrespective of their attributes. In their presence, instead, firms choose to serve a market only if the revenue from it is sufficiently high to justify paying the fixed cost.

Given that prices are a constant markup over the marginal cost, profits earned in market d are a fraction σ_i of revenue minus the fixed cost $w_o f_{doi}$:

$$\pi_{doi}(\phi) = \frac{r_{doi}(\phi)}{\sigma_i} - w_o f_{doi}. \quad (7)$$

Since $r_{doi}(\phi)$ is an increasing function, a firm finds it profitable to serve market d (i.e., $\pi_{doi}(\phi) > 0$) if and only if ϕ is sufficiently high. Define ϕ_{doi}^* and r_{doi}^* as the minimum ϕ and the minimum revenue, respectively, such that a firm breaks even in market d :

$$\pi_{doi}(\phi_{doi}^*) = 0 \iff r_{doi}^* = \sigma_i w_o f_{doi}. \quad (8)$$

In order to make sure that exporters are always a subset of the firms that operate locally, the costs of exporting, τ_{doi} and f_{doi} , are assumed to be sufficiently high to guarantee $\phi_{ooi}^* < \phi_{doi}^*$. In words, the domestic market is always more profitable than any other foreign market.

Firm attributes are determined at the entry stage. Upon paying an entry cost of F_{oi} units of labor, firms draw attributes from a known distribution. Although attributes are two-dimensional (φ, γ) , the equilibrium allocation only depends on their product, $\phi \equiv \varphi\gamma$. Hence, it suffices to consider the distribution $G_{oi}(\phi)$ from which ϕ is drawn. After observing ϕ , the firm decides in which markets, if any, to sell. If $\phi < \phi_{ooi}^*$, the firm would make negative profits even in the domestic market and hence it exits immediately. For this reason, ϕ_{ooi}^* is

² Arkolakis (2010) provides a generalization of the model in which the cost of accessing a market depends on the number of customers that the firm wants to serve.

called the exit cutoff. Similarly, the minimum appeal needed to make positive profits in a destination, ϕ_{doi}^* , is called the export cutoff for market $d \neq o$. Firms with better attributes (higher ϕ) can sell larger quantities and hence find it profitable to enter markets with higher fixed costs. As a result, they serve more destinations.

Entry decisions are made before knowing the realization of ϕ and hence depend on expected profits. In particular, expected profits from selling to market d are:

$$\mathbb{E}[\pi_{doi}] = \int_{\phi_{doi}^*}^{\infty} \pi_{doi}(\phi) dG_{oi}(\phi). \quad (9)$$

For future reference, it is important to note that, other things equal, $\mathbb{E}[\pi_{doi}]$ is a negative function of the cutoff ϕ_{doi}^* . Intuitively, expected profits are lower from markets that are harder to reach, because firms have a lower probability to be able to serve them. Free entry implies that entry continues until the cost of creating a new firm, $w_o F_{oi}$, is equal to its expected value:

$$w_o F_{oi} = \mathbb{E}[\pi_{ooi}] + \sum_{d \neq o} \mathbb{E}[\pi_{doi}], \quad (10)$$

where the two terms on the right-hand side separate expected profits from domestic and foreign sales.

Finally, combining the break-even condition for the marginal firm, $r(\phi_{ooi}^*) = \sigma_i w_o f_{ooi}$, with (6) and substituting expenditure $E_{oi} = \beta_i w_o L_o$, it is possible to solve for the price index:

$$P_{oi} = \frac{\sigma_i}{\sigma_i - 1} \left(\frac{\sigma_i f_{ooi}}{\beta_i L_o} \right)^{\frac{1}{\sigma_i - 1}} \frac{w_o}{\phi_{ooi}^*}, \quad (11)$$

where L_o is labor supply in country o . Equation (11) shows that a higher exit cutoff, i.e., more selection, implies lower prices. Solving (11) for w_o/P_{oi} also shows that the effect of the distribution of firm attributes on real wages is entirely summarized by its effect on the exit cutoffs. Finally, the wage w_o does not depend on the industry equilibrium. It may be pinned down by a sector producing a homogeneous good that is freely traded. Or it may be determined in general equilibrium by the equality between income and world expenditure on all the goods produced by the country.

2.2 TRADE AND SELECTION

Equation (6) can be used to express revenues as a function of the minimum level (r_{doi}^*) needed to serve the market and ϕ :

$$r_{doi}(\phi) = r_{doi}^* \left[\frac{\phi}{\phi_{doi}^*} \right]^{\sigma_i - 1}. \quad (12)$$

Using (12), (7) and (8) into the free-entry condition (10) yields:

$$F_{oi} = f_{doi} \sum_d \int_{\phi_{doi}^*}^{\infty} \left[\left(\frac{\phi}{\phi_{doi}^*} \right)^{\sigma_i - 1} - 1 \right] dG_{oi}(\phi). \quad (13)$$

Each element on the right-hand side is a negative function of the cutoff ϕ_{doi}^* only. This implies that if the export cutoffs fall, for instance due to trade liberalization, the exit cutoff, ϕ_{oai}^* , must rise so as to satisfy the free-entry condition. This is the selection effect of trade: export opportunities force the least productive firms to exit. The intuition for this important result is that higher export profits induce more entry and hence tougher selection on the domestic market. Crucial for this result is the fact that the least productive firms serve the domestic market only, implying that their loss in domestic revenue due to more entry is not compensated by any gain in foreign markets.

In turn, export opportunities depend solely on the cutoffs ϕ_{doi}^* , which can be obtained from (6) and (11):

$$\phi_{doi}^* = \tau_{doi} \left(\frac{f_{doi}}{f_{ddi}} \right)^{1/(\sigma_i - 1)} \left(\frac{w_o}{w_d} \right)^{\sigma_i/(\sigma_i - 1)} \phi_{ddi}^*. \quad (14)$$

The export cutoff is a positive function of the export costs, τ_{doi} and f_{doi} , and of competition in the destination market, as summarized by the exit cutoff of domestic firms in that market, ϕ_{ddi}^* . It is also a negative function of the competitiveness of origin o , as summarized by the wage relative to local firms in the destination, w_o/w_d . Given wages, equations (13) and (14) form an autonomous system that can be solved for all the cutoffs ϕ_{doi}^* .

The selection effect of trade raises welfare. As implied by equation (11), the real wage, expressed in terms of the price index of any sector i , is an increasing function of the exit cutoff in the sector. Hence, welfare increases with more selection, despite the loss of small domestic firms. Intuitively, trade liberalization lowers prices, which is good for consumers even if it forces some marginal firms out of business. The strength of the selection effect can vary across sectors and countries. It is stronger in sectors with better export opportunities, such as lower export costs, and in countries with lower wages. By the same logic, adding differences in factor intensity across sectors and in factor abundance across countries, Bernard, Redding and Schott (2007) also show that selection is stronger in comparative advantage sectors.

2.3 FIRM HETEROGENEITY AND THE VOLUME OF TRADE

Consider now the implications of the model for the volume of trade. Exports from origin o to destination d can be decomposed into an extensive margin N_{doi} , equal to the number

exporters, and an intensive margin \bar{r}_{doi} , equal to average export per firm:

$$X_{doi} = N_{doi} \cdot \bar{r}_{doi}. \quad (15)$$

The extensive margin is given by the number of active firms in o , N_{oi} , times the probability to export:

$$N_{doi} = N_{oi} [1 - G_{oi}(\phi_{doi}^*)]. \quad (16)$$

Using (12), (8) and (14), the intensive margin can be expressed as:

$$\bar{r}_{doi} = \frac{(w_o \tau_{doi})^{1-\sigma_i}}{\Gamma_{di}} \int_{\phi_{doi}^*}^{\infty} \phi^{\sigma_i-1} \frac{dG_{oi}(\phi)}{1 - G_{oi}(\phi_{doi}^*)}, \quad (17)$$

where $\Gamma_{di} = (\phi_{ddi}^*)^{\sigma_i-1} / (\sigma_i w_d^{\sigma_i} f_{ddi})$ summarizes the toughness of competition in destination d .

Firm heterogeneity matters both for how the two margins react to variable trade costs and for the overall volume of exports. With homogeneous firms, as in Krugman (1980), the extensive margin is muted: all firms (or none of them) export, and any decline in variable trade costs increases average export per firm only. In the heterogeneous-firms model, a decline in variable trade costs induces more firms to export. However, the reaction of the extensive margin weakens the intensive margin: while existing exporters sell more, new exporters are less productive and hence export smaller quantities. This second effect tends to lower average export per firm. Which effect dominates depends on the distribution $G_{oi}(\phi)$. For instance, if $G_{oi}(\phi)$ is Pareto, the two effects exactly offset each other (Chaney, 2008). If it is Log-Normal, the first effect dominates, so that export per firm increases (Bas, Mayer and Thoenig, 2017, Fernandes et al., 2018).

The extent of heterogeneity is also a direct determinant of the volume of trade. More dispersion in the distribution $G_{oi}(\phi)$ shifts probability in the tails and this can increase the fraction of firms that are sufficiently productive to export. If this is the case, more heterogeneity will increase the extensive margin of trade. But heterogeneity can also increase the intensive margin of trade. To see this, note from equation (17) that export per firm is a convex function of ϕ when $\sigma_i > 2$. In this empirically plausible case, Jensen's inequality implies that \bar{r}_{doi} increases with dispersion. The intuition for this result is that, if varieties are sufficiently substitutable, consumers reallocate demand from less to more desirable varieties more than proportionally. In this case, more heterogeneity is also associated with a higher value of entry, more selection and higher welfare (see Bonfiglioli, Crinò and Gancia, 2020, and Epifani and Gancia, 2011, for an earlier result).

2.4 TRADE, MARKET SIZE AND THE PRO-COMPETITIVE EFFECT

In the benchmark model, market size does not affect selection. Moreover, neither market size nor international trade affect markups. This is because demand is CES and firms are infinitesimal. In reality, however, the number of firms is discrete and top firms have non-negligible market shares. In this case, markups become endogenous and are affected by trade. This has been shown by Atkeson and Burstein (2008), Amiti, Itskhoki and Konings (2014, 2019), and Gaubert and Itskhoki (2021), who consider a version of the model in which the number of firms is discrete.³

Firms play a Bertrand-Nash game whereby the price of a variety ω sold in destination d , $p_d(\omega)$, is chosen so as to maximize profits in the destination market, taking as given the prices of all competitors.⁴ In equilibrium, the markup is an inverse function of the perceived demand elasticity, $\epsilon_d(\omega)$:

$$p_d(\omega) = \frac{\epsilon_d(\omega)}{\epsilon_d(\omega) - 1} \frac{\tau_d(\omega)w(\omega)}{\varphi(\omega)}. \quad (18)$$

The novelty is that, since firms are large, the perceived demand elasticity depends on the market share $s_d(\omega)$ captured by the variety:

$$\epsilon_d(\omega) = [1 - s_d(\omega)] \sigma_i + s_d(\omega), \quad (19)$$

where:

$$s_d(\omega) = \frac{[\gamma(\omega)/p_d(\omega)]^{\sigma_i-1}}{\sum_{\omega \in \Omega_i} [\gamma(\omega)/p_d(\omega)]^{\sigma_i-1}}. \quad (20)$$

Given the set of varieties in industry i , conditions (18)-(19)-(20) form a system of equations with a unique solution. In a sequential entry game where firms with better attributes enter destination markets first, there exists a unique cutoff ϕ_{doi}^* such that all firms from origin o with $\phi > \phi_{doi}^*$ sell to country d .

Firms with better attributes, i.e., a higher ϕ , capture larger market shares, charge higher markups, and make more profits. Moreover, the elasticity of the markup with respect to the market share is an increasing function of the market share itself:

$$-\frac{d \ln \epsilon_d(\omega)}{d \ln s_d(\omega)} = \frac{s_d(\omega) (\sigma_i - 1)}{\sigma_i - s_d(\omega) (\sigma_i - 1)}. \quad (21)$$

This means that the markups charged by large firms react more to any change in their

³An alternative way to make markups endogenous is to consider non-CES demand, as in Melitz and Ottaviano (2008), Mrazova and Neary (2017) or Arkolakis et al. (2019).

⁴Since ω already identifies the industry and origin of a variety, the indexes i and o can be omitted. However, the price of the same variety may differ across destination markets.

market share.⁵ The new result is that any increase in market size causes firms to lower their markups. This is the so-called pro-competitive effect. Moreover, since better firms lower markups relatively more, market shares are also reallocated across firms. This also implies that, if foreign competition intensifies in any destination, sales from a given origin become more concentrated.

3 TRADE WITH HETEROGENEOUS FIRMS: EVIDENCE

The increased availability of micro-level data sparked an enormous amount of empirical research on the role of firms in international trade. Using datasets that allow researchers to distinguish between exporting and non-exporting firms, earlier contributions have unveiled important facts about the characteristics of exporters, and leveraged episodes of trade liberalization to provide evidence on the selection effect and intra-industry reallocations induced by trade. More recently, researchers shifted attention to transaction-level datasets, uncovering new stylized facts and testing additional implications of the model. Section 3.1 summarizes the main findings in the earlier literature, while Section 3.2 turns to more recent research using transaction-level data.

3.1 EXPORTER CHARACTERISTICS, SELECTION AND REALLOCATION

The seminal paper by Bernard and Jensen (1995) unveils a number of important facts about exporting firms and export participation. First, in any given industry, only a minority of firms sell their products abroad: exporting is a rare activity. Second, exporters are not a random sample of the population of firms; rather, they are systematically larger and more productive than non-exporters. Both facts are confirmed by Bernard et al. (2018), who use data for the US in 2007. The authors document that exporters represent only 35% of US manufacturing firms and sell on average only 17% of their output abroad. Moreover, relative to non-exporting firms in the same industry, exporters are larger both in terms of employment (by 111%) and in terms of sales (by 135%). Exporters are also more productive than non-exporters, both in terms of value added per worker (by 19%) and in terms of Total Factor Productivity (by 4%).⁶ Both the limited export participation and the better performance of exporters are confirmed by virtually all existing studies, not only for other industrialized countries but also for transition and developing economies.

The existence of a productivity premium for exporters is consistent with two explanations. Either exporting firms are more productive than non-exporters before entering international

⁵Similarly, the markup elasticity with respect to the firm's own price and to the price of competitors is also increasing in the market share (see Amiti, Itskhoki and Konings, 2014, 2019).

⁶Bernard et al. (2018) also find marked differences in terms of capital intensity, skill intensity, and average wages in favor of exporting firms.

markets ("selection") or productivity improves after exporting ("learning-by-exporting"). Bernard and Jensen (1997) provide compelling evidence of the selection of more productive firms into exporting, by showing that productivity differences between future exporters and non-exporters antedate the moment in which exports begin. Similar evidence of selection has been found for many other countries. By contrast, evidence on learning-by-exporting is mixed. For instance, Clerides, Lach, and Tybout (1998) and Bernard and Jensen (1999) find no evidence of productivity gains from exporting, respectively, in Mexican, Colombian and Moroccan firms and in US firms. Conversely, Van Biesebroeck (2005) and De Loecker (2007) document productivity improvements after export market entry in Sub-Saharan and Slovenian enterprises, respectively. Overall, these facts suggest that exporting is a costly activity, which only some firms find it profitable to undertake. In particular, the evidence is consistent with the existence of fixed costs of exporting, which only the most productive firms can afford to incur.

As shown in the previous section, in the presence of heterogeneous firms and fixed costs of exporting, trade liberalization reduces sales of less productive firms, forcing the least productive ones to exit the market, and increases sales of more productive firms. The resulting reallocations of market shares raise aggregate industry productivity, providing an additional source of gains from trade. Some studies have investigated these effects exploiting large episodes of trade liberalization. Pavcnik (2002) examines the case of Chile, which underwent a rapid fase of tariff reductions between 1979 and 1986. Using data from the census of manufacturing plants with ten or more employees, the author shows that firm exit played an important role during the Chilean trade liberalization, with more than 35% of firms that were active in 1979 ceasing operations by 1986. Exiting firms were less productive than surviving firms, by 8% on average. Moreover, trade liberalization reallocated market shares in favor of more productive firms among the survivors. These reallocations accounted for two-thirds of the 19% increase in aggregate productivity experienced by the Chilean manufacturing sector over the study period. Both exit and reallocations were stronger in trade-oriented sectors than in non-traded sectors.⁷

Similar evidence of trade-induced reallocations was found for industrialized countries. In particular, Treffer (2004) documents reallocations of market shares among Canadian firms as a result of the tariff reductions brought about by the North American Free Trade Agreement. Similarly, Bernard, Jensen and Schott (2006), di Giovanni, Levchenko and Ranciere (2011), and di Giovanni and Levchenko (2012) document reallocations induced by trade liberalization

⁷The remaining one-third of productivity growth in Chile was due to improvements in within-firm productivity. While in the model illustrated in the previous section firm attributes are given, various studies have shown that trade liberalization could increase firm productivity by raising returns to investment in advanced technologies. See, in particular, Verhoogen (2008), Khandelwal and Topalova (2011), Lileeva and Treffer (2011), Bustos (2011), and Crinò and Epifani (2012) for empirical evidence on Mexico, India, Canada, Argentina, and Italy, respectively.

and new export opportunities in the US, France, and the fifty largest economies in the world, respectively.

3.2 HETEROGENEITY, MARGINS OF TRADE AND THE PRO-COMPETITIVE EFFECT

A more recent literature, initiated by Bernard, Jensen and Schott (2009), has taken advantage of the increasing availability of transaction-level datasets to shed further light on the role of heterogeneity in trade. This literature has also provided evidence on additional implications of the theory, especially those regarding the role of top firms in trade flows and the pro-competitive effect of trade.

This section summarizes the main results in this literature. It does so with the help of rich transaction-level data on US imports from Piers, a database administered by IHS Markit. The version of Piers used in this article contains values and quantities for the universe of seaborne manufacturing import transactions of the US, disaggregated by origin country, exporting firm, and 6-digit code of the Harmonized System product classification (HS6), in two years, 2002 and 2012. In what follows, "varieties" are defined as firm-product pairs; they are assigned to industries by mapping each HS6 product exported by a foreign firm to the US into a 4-digit code of the Standard Industrial Classification (SIC). The final dataset comprises 1,311,835 observations at the firm-product-year level. Firms belong to 366 4-digit SIC manufacturing industries and 104 origin countries spanning the five continents. The average country-industry-year triplet has 43 firms, 53 varieties, and average export per variety approximately equal to \$1.2 million.⁸

3.2.1 *Heterogeneity and Top Firms across Sectors*

Existing studies have highlighted two important characteristics of trade flows. First, in any origin country, the value of exports to any destination market varies markedly across firms and products, even within the same narrowly-defined industry. Second, the vast majority of a country's exports in any industry is accounted for by very few and extremely large firms. This section summarizes these results and illustrates the main facts about heterogeneity and concentration in trade flows using the Piers data.

Bonfiglioli, Crinò and Gancia (2019) quantify the extent of heterogeneity in trade flows using official data on US imports at the product level for the 1989-2006 period and measuring heterogeneity by the standard deviation of log sales across products within each origin country and 4-digit industry. The results show that heterogeneity is high (1.94 on average in 2006) and

⁸See Bonfiglioli, Crinò and Gancia (2020, 2021) for more details on the Piers data. Seaborne trade is the main mode of importing goods into the US. It accounts for 53% of total US merchandise imports in 2012, according to official data from the US Customs. Seaborne trade also accounts for 85% of overall US manufacturing imports for the median country-industry pair in the sample.

Table 1: Heterogeneity and Top Firms across Sectors

	Variance of log exports across varieties			Share of exports by the top-4 varieties		
	Mean	Std. Dev.	Change	Mean	Std. Dev.	Change
	(2012)	(2012)	(2002-2012)	(2012)	(2012)	(2002-2012)
	(1)	(2)	(3)	(4)	(5)	(6)
20 Food and kindred products	2.906	2.527	0.282	0.778	0.203	-0.015
21 Tobacco products	3.173	3.882	0.638	0.893	0.137	0.060
22 Textile mill products	3.206	2.385	0.199	0.792	0.216	0.036
23 Apparel products	3.382	3.000	0.238	0.707	0.272	0.024
24 Lumber and wood products	2.829	2.106	0.113	0.773	0.218	0.039
25 Furniture and fixtures	3.107	2.281	0.151	0.782	0.234	0.046
26 Paper and allied products	3.558	2.934	0.596	0.794	0.209	-0.016
27 Printing and publishing	3.291	2.754	-0.392	0.772	0.214	0.010
28 Chemical products	4.012	3.550	0.153	0.790	0.211	0.012
29 Petroleum refining	5.319	5.671	0.829	0.905	0.111	0.015
30 Rubber and plastics products	3.458	2.349	-0.131	0.744	0.232	0.008
31 Leather and leather products	3.363	2.870	0.088	0.755	0.231	-0.010
32 Non-metallic mineral products	3.353	2.873	-0.235	0.804	0.217	0.042
33 Primary metal industries	4.681	4.063	0.744	0.834	0.189	0.030
34 Fabricated metal products	3.526	2.602	-0.162	0.790	0.216	-0.008
35 Machinery and computer	3.849	3.651	0.181	0.782	0.221	-0.027
36 Electronic equipment	4.127	3.285	-0.120	0.820	0.201	-0.018
37 Transportation equipment	2.996	2.200	0.125	0.804	0.204	-0.003
38 Precision instruments	3.840	3.143	-0.182	0.826	0.205	-0.026
39 Miscellaneous manufacturing	3.281	2.736	-0.094	0.768	0.234	-0.013
20-39 Manufacturing	3.549	3.080	0.119	0.784	0.220	0.001

Notes. Source: Piers (IHS Markit), US seaborne import data by exporting firm and 6-digit HS product in 2002 and 2012. A variety is a firm-product pair. All statistics are computed across all origin countries and 4-digit SIC manufacturing industries belonging to a given sector. The sample includes 104 origin countries and 366 4-digit manufacturing industries.

has increased over time (by 6% on average over 1989-2006). Table 1 confirms this evidence using firm-level rather than product-level data. Heterogeneity is measured by the variance of log sales across varieties, and is computed separately for each origin country and 4-digit industry. Descriptive statistics for each 2-digit manufacturing sector are computed across all countries and 4-digit industries belonging to it. The last row of the table reports aggregate statistics for the entire manufacturing sector. In manufacturing as a whole, the variance of log exports to the US equals 3.5 on average in 2012, and has increased by an average 12% between 2002 and 2012. The variance of log sales is large in all sectors and has grown in most of them.

Table 1 provides additional empirical regularities about heterogeneity, in particular, by showing that its extent varies considerably across sectors. The variance of log sales is especially large in high-tech sectors—e.g., electronic equipment, machinery and computers, and precision instruments—and in sectors dominated by few large firms—e.g., chemicals, petroleum refining, and primary metal industries. Heterogeneity is instead more limited in

traditional industries, such as food and kindered products, lumber and wood products, textile, and apparel. In light of the model, variation in heterogeneity across sectors reflects both technological characteristics, i.e., differences in the distributions $G_{oi}(\phi)$, but also varying degrees of firm selection into exporting.⁹

The high heterogeneity in trade flows suggests that large and small exporters tend to coexist within any country-industry pair. The literature has also shown, however, that the vast majority of exports from any country is accounted for by a handful of top firms. In other words, trade flows are also extremely concentrated. Bernard et al. (2018) show that the top 1% of firms account for more than 80% of US trade. Freund and Pierola (2015) find that the top-5 firms account on average for 30% of total exports in 32 mostly developing countries. Gaubert and Itskhoki (2021) report that the largest firm in France accounts for 7% of all French manufacturing exports, and that within narrow industries the top exporter accounts for 28% of industry exports on average.

The remaining columns of Table 1 illustrate the concentration in trade flows by reporting statistics on the share of exports to the US accruing to the top-4 varieties in each origin country and 4-digit industry. Foreign sales in the US are highly concentrated: in the average country-industry pair, the top-4 varieties account for 78% of US imports in 2012. While some variation exists across sectors, the share of exports by the top-4 varieties never falls below 70% (apparel products) and reaches a maximum of 91% in the most concentrated sector (petroleum refining).

Another interesting aspect highlighted by Table 1 is that concentration in trade flows has remained essentially constant over time. In manufacturing as a whole, the average change in the share of US imports accruing to the top-4 varieties was a meager 0.1 percentage points over 2002-2012. This fact sharply contrasts with the evolution of concentration among US firms, which has markedly increased over the same time period. Table 1 shows that two forces have contributed to keeping concentration in US imports stable. First, concentration has evolved differently across sectors, increasing in half of them and decreasing in the remaining ones. Second, and more importantly, changes in concentration have been quite small in most sectors.¹⁰ Bonfiglioli, Crinò and Gancia (2021) dig deeper into the latter result. They show that the small changes in the concentration of US imports within sectors resulted from the opposing role played by the extensive and the intensive margin of trade. Pushing towards lower concentration, the number of exporting firms has grown and the number of exported products has fallen relatively more for top firms. On the contrary, the average revenue per

⁹See Helpman, Melitz and Yeaple (2004) and Bonfiglioli, Crinò and Gancia (2018) for additional evidence on the cross-sectoral variation in heterogeneity using data on aggregate sales for Europe and the US, respectively.

¹⁰Consistent with Table 1, Freund and Sidhu (2017) find that global industrial concentration did not increase and, if anything, actually declined in most industries. Yet, they do so combining national data. Hence, they study concentration among producers in the world, not in any destination market.

product of top firms significantly increased relative to the population average. These results show that both entry and reallocations towards top firms are important to understand the distribution of sales across firms and the dynamics of concentration.

3.2.2 Heterogeneity and the Margins of Trade

As discussed in Section 2.3, overall exports to any destination market can be decomposed into two margins: an extensive margin, measuring the number of exported varieties, and an intensive margin, measuring average export per variety. Moreover, firm heterogeneity and selection affect both margins. This section considers three main empirical applications of the decomposition. The first is to unpack the sources of trade growth. In particular, the decomposition assesses to what extent the observed change in overall exports is driven by changes in the number of exported varieties or in average sales per variety. The second application is to quantify the sources of variation in trade flows across origin countries and industries. In other words, the decomposition measures the extent to which larger trade flows in some countries and industries depend on each margin. The third application of the decomposition is to assess the role of firm heterogeneity in driving the margins of trade.

Panel a) of Table 2 shows results for the first application. To this purpose, the panel quantifies the contributions of the extensive and the intensive margin to the growth in overall exports to the US within each country-industry pair. Reported figures are averages computed across all country-industries in the sample. In the average country-industry, overall exports to the US increased by 0.046 log points over 2002-2012. This growth has resulted from two opposing forces: while average export per variety fell by 0.113 log points, the number of exported varieties increased more than proportionately, by 0.159 log points. Hence, the two margins have contributed differently to the growth in overall exports to the US in the average country-industry pair: while the intensive margin pushed towards a reduction in exports, the extensive margin worked in the opposite direction, and the latter effect has dominated the former.

This finding is consistent with an increase in the number of small exporters, and illustrates once again the importance of selection and firm heterogeneity for understanding trade flows. Data by destination market, rather than by origin country, confirm this interpretation. For instance, using US export data, Bernard et al. (2009) show that the negative effect of distance on bilateral trade flows is accounted for by the extensive margin. Using French export data, Eaton, Kortum and Kramarz (2011) find that the number of firms selling to a market increases with market size, and that firms selling to more and smaller destinations also have higher sales in France. The importance of the extensive margin was also stressed by Helpman, Melitz and Rubinstein (2008), who recognized that models with heterogenous firms provide

Table 2: Margins of Trade

a) <u>Margins of export growth</u>		
	Change in log N. of varieties	Change in log average export per variety
Mean	0.159	-0.113
b) <u>Variance decomposition, levels</u>		
	Log N. of varieties	Log average export per variety
ln tot. exp.	0.466*** [0.003]	0.534*** [0.003]
c) <u>Variance decomposition, changes</u>		
	Change in log N. of varieties	Change in log average export per variety
Δ ln tot. exp.	0.235*** [0.005]	0.765*** [0.005]

Notes. Panel a) reports averages, computed across country-industry pairs, of the variables indicated in the columns' headings. Panel b) reports coefficients and heteroskedasticity-robust standard errors from OLS regressions, estimated across country-industry-year triplets (24,693 observations), of the variables indicated in the columns' headings on log total exports. Panel c) reports coefficients and heteroskedasticity-robust standard errors from OLS regressions, estimated across country-industry pairs (9,864 observations), of the variables indicated in the columns' headings on the change in log total exports. ***, **, *: denote significance at the 1, 5 and 10% level, respectively.

a rationale for the prevalence of zeros in bilateral trade flows, with important implications for the estimation of the effect of trade frictions.

The remainder of Table 2 reports results for the second application of the decomposition, by breaking down the overall variance of foreign sales in the US into the two margins. Panel b) focuses on export levels. It reports coefficients and standard errors obtained by regressing the log of each margin on the log of overall exports to the US, across all country-industry-year triplets in the sample. The properties of OLS imply that the coefficients obtained from the two regressions add up to one. Thus, each coefficient provides the percentage contribution of the corresponding margin to explaining the variance of overall exports to the US across triplets. The results show that the two coefficients have roughly the same size. Hence, each margin accounts for approximately half of the variation in overall exports: triplets characterized by larger exports display both a larger number of exported varieties and greater average export per variety, with the contributions of the two margins being roughly equivalent in the data.¹¹ Panel c) performs a similar variance decomposition for the change in exports.

¹¹While the two margins are correlated, by the properties of OLS this decomposition allocates the covariance equally between the two terms.

Reported figures are coefficients and standard errors obtained by regressing the log change in each margin on the log change in overall exports, across all country-industry pairs in the sample. The results show that roughly three fourths of the variance of export growth across country-industries are explained by the intensive margin, with the remaining one fourth being accounted for by the extensive margin.

The above results are consistent with several decomposition exercises in the literature. In particular, Hummels and Klenow (2005) were the first to document the importance of both the intensive and the extensive margin at the product level for the volume of trade. More recent papers have confirmed these results using firm-level data for various countries (Fernandes, Freund and Pierola, 2016, Bernard et al. 2018, Fernandes et al., 2018, Bonfiglioli, Crinò and Gancia, 2020).

The third application of the decomposition is to study the role of firm heterogeneity in explaining the volume of trade. As shown in Section 2.3, in the benchmark model, heterogeneity should have positive effects on both margins. The results are summarized in Table 3. Panel a) reports coefficients from regressions of log total exports to the US, log number of exported varieties, and log average export per variety on log heterogeneity, measured by the variance of log sales; each regression is estimated across all country-industry-year triplets in the sample. The specifications in columns (1)-(3) do not include control variables, while the regressions in columns (4)-(6) control for country-year and industry-year fixed effects. All coefficients are positive and very precisely estimated, confirming that greater heterogeneity is associated with larger exports, more exported varieties, and greater export per variety. Up to 75% of the correlation between heterogeneity and overall exports is explained by the intensive margin, with the remaining fraction being due to the extensive margin. Panel b) performs a similar exercise, but with variables in changes rather than in levels. Also in this case, an increase in heterogeneity within a country-industry pair is associated with increases in the number of exported varieties, in average export per variety, and hence in overall exports. The intensive margin contributes approximately 85% to the relationship between changes in heterogeneity and changes in overall exports. These results are consistent with Redding and Weinstein (2017) and Bonfiglioli, Crinò and Gancia (2020), who provide structural decompositions showing that more heterogeneity in firm attributes is associated with higher average sales per firm.

Finally, it is important to recognize that these exercises document the importance of firm heterogeneity, but do not study where it comes from. A set of papers has studied the origin of firm heterogeneity by providing structural decompositions of the distribution of firm sales into the contributions of costs (the parameter φ in the model), demand shifters (γ), markups ($\epsilon(\omega)/(\epsilon(\omega) - 1)$) and product scope (the number of varieties per firm). These papers show that product scope, entry/exit and demand shifters explain a large fraction

Table 3: Heterogeneity and Trade

	(1)	(2)	(3)	(4)	(5)	(6)
a) <u>Regressions in levels</u>						
	Log total exports	Log N. of varieties	Log avg. export per variety	Log total exports	Log N. of varieties	Log avg. export per variety
ln heterogeneity	0.883*** [0.019]	0.355*** [0.007]	0.527*** [0.014]	0.599*** [0.016]	0.138*** [0.005]	0.461*** [0.014]
Obs.	23888	23888	23888	23888	23888	23888
R2	0.23	0.11	0.20	0.54	0.66	0.39
Country-year FE	No	No	No	Yes	Yes	Yes
Industry-year FE	No	No	No	Yes	Yes	Yes
b) <u>Regressions in changes</u>						
	Change in log total exports	Change in log N. of varieties	Change in log avg. export per variety	Change in log total exports	Change in log N. of varieties	Change in log avg. export per variety
Δ ln heterogeneity	0.586*** [0.024]	0.102*** [0.006]	0.484*** [0.021]	0.546*** [0.023]	0.075*** [0.006]	0.470*** [0.021]
Obs.	9581	9581	9581	9581	9581	9581
R2	0.18	0.03	0.17	0.34	0.41	0.28
Country FE	No	No	No	Yes	Yes	Yes
Industry FE	No	No	No	Yes	Yes	Yes

Notes. Heterogeneity is the variance of log exports across firm-product pairs within a country-industry-year triplet. Regressions are estimated with OLS across country-industry-year triplets (panel a) or country-industry pairs (panel b). Dependent variables are indicated in columns' headings. Standard errors, reported in square brackets, are robust to heteroskedasticity. ***, **, *, denote significance at the 1, 5 and 10% level, respectively.

of the variation in the data, with a minor role for prices (hence, costs and markups). In particular, using US barcode data, Hottman, Redding and Weinstein (2016) find that 50-70% of the variance in firm sales can be attributed to differences in firm appeal, about 20-25% to differences in product scope, and less than 25% to costs. Using US import data, Redding and Weinstein (2017) find that around 50% of the cross-section (90% of the time-series) variation in comparative advantage is accounted for by variety and average demand/quality, with average prices contributing less than 10%.

3.2.3 International Competition and Reallocation

The evidence discussed so far suggests that trade flows are dominated by a small number of large firms. As shown in Section 2.4, in such a granular world, market power is likely to be endogenous and to vary across firms. In that case, intensified foreign competition in a destination market induces firms to lower their markups. However, the reaction is asymmetric. Since top firms cut their markups more, competition reallocates market shares towards these firms. This implies that, in models with heterogeneous firms, more international competition can lead to lower markups but also more concentration in sales from any given origin country.

Evidence on the pro-competitive effect was initially focused on average markups. Tybout (2003) surveys earlier studies showing that markups generally fall with import competition. More recent work using transaction-level data was directed to identifying heterogeneity in the reaction of firms and their aggregate consequences. Using Belgian firm-product-level data,

Amiti, Itskhoki and Konings (2014, 2019) find that small firms have nearly complete exchange rate and cost pass-through to prices. In contrast, prices charged by large firms respond to both competitor price changes and own cost shocks, with roughly equal elasticities of around one half. The authors also find that these asymmetries in markup variability across firms is important for explaining the aggregate markup response to international shocks. Other papers have studied the effect of import competition on reallocations. Amiti and Heise (2021), using firm-level data from the US census, show that import competition causes an increase in domestic market concentration. Contrary to papers using national data only, the authors also find that market concentration remained stable, or even fell over time, when foreign imports are included. Similarly, Bonfiglioli, Crinò and Gancia (2021) show that international competition in the US market reallocated market shares towards the top exporters in each origin country and industry, thereby raising the concentration of exports among national firms. Overall, this evidence supports the prediction of heterogeneous-firms models that, in global markets, stronger competition can coexist with growing national concentration.

This section provides evidence on the effect of international competition on reallocation towards top firms using regression analysis similar to the one in Bonfiglioli, Crinò and Gancia (2021). In particular, the change in the share of US imports accruing to the top-4 varieties in each origin country and industry is regressed on proxies for competition both at the country-industry and at the industry level. The regression coefficients are conditional correlations highlighting the central tendencies in the data. The results are reported in Table 4. In column (1), the change in concentration is regressed on a number of country-industry variables: the changes in the number of exported varieties and in average price per variety, the initial value of concentration, and the initial share of the country in US imports within the industry. All variables are in logs and all specifications include country fixed effects.¹² As expected, concentration declines with entry. It also falls more in countries capturing larger initial shares of US imports in an industry. Moreover, in country-industries where concentration is initially higher, there is a greater tendency for mean reversion.

That concentration increases with exit is not informative about its correlation with competition. To search for evidence of the pro-competitive effect, the next columns add industry-level controls. Column (2) includes the change in the number of varieties exported to the US in an industry from other origin countries, the change in the industry share of US imports, and the change in the overall concentration of US imports in the industry. Domestic concentration increases with entry of foreign competitors and in expanding sectors. These results are consistent with the pro-competitive effect highlighted in the model: both foreign entry and industry growth likely indicate higher competitive pressure, lower market shares

¹²The country fixed effects allow focusing on cross-industry variation within countries and control for country-specific characteristics that do not vary across industries (e.g., distance from the US, institutional quality, etc.).

Table 4: International Competition and Reallocation

	(1)	(2)	(3)	(4)
$\Delta \ln$ no. of varieties	-0.202*** [0.005]	-0.219*** [0.006]	-0.225*** [0.007]	-0.201*** [0.006]
$\Delta \ln$ average price per variety	0.004 [0.004]	-0.003 [0.004]	-0.006 [0.005]	-0.009** [0.004]
Initial \ln share of sales by the top-4 varieties	-0.317*** [0.012]	-0.328*** [0.012]	-0.336*** [0.014]	-0.495*** [0.014]
Initial \ln country share of US imports in the industry	-0.033*** [0.002]	-0.037*** [0.002]	-0.041*** [0.002]	-0.054*** [0.002]
$\Delta \ln$ N. of varieties from other countries		0.034*** [0.008]	0.030*** [0.010]	0.226** [0.092]
$\Delta \ln$ industry share of total US imports		0.025*** [0.005]	0.030*** [0.006]	
$\Delta \ln$ share of sales by top-4 varieties in the industry		0.040*** [0.006]	0.054*** [0.007]	
\ln elasticity of substitution			0.039*** [0.006]	
Obs.	7198	7195	5461	7195
R2	0.40	0.41	0.43	0.50
Country FE	Yes	Yes	Yes	Yes
Industry FE	No	No	No	Yes

Notes. All regressions are estimated with OLS across country-industry pairs. The dependent variable is the change in the log share of exports by the top-4 varieties in a country-industry pair between 2002 and 2012. The elasticity of substitution in an industry is estimated using the Reverse-Weighting estimator (Redding and Weinstein, 2016). Standard errors, reported in square brackets, are robust to heteroskedasticity. ***, **, *: denote significance at the 1, 5 and 10% level, respectively.

for existing firms, and hence more concentrated sales. The positive coefficient on the change in concentration at the industry level points instead to the existence of common trends across origins.

Column (3) further controls for the elasticity of substitution.¹³ Concentration increases more in sectors where varieties are more substitutable. This also is consistent with the pro-competitive effect, as the latter should lower markups and prices, and skew the distribution of sales towards top firms, especially in industries with a high elasticity of substitution. Finally, column (4) replaces the industry-level variables with industry fixed effects. The results confirm the negative correlation between changes in concentration and changes in the number of competitors from the same origin country. Moreover, the coefficient on the change in average price per variety is now negative and precisely estimated, suggesting growing concentration to be associated with declining prices. The results also confirm the positive association between changes in concentration and entry of foreign competitors.

¹³The elasticity of substitution is estimated using the Reverse-Weighting estimator introduced by Redding and Weinstein (2016). Since estimates of this parameter are not available for all industries, the number of observations is reduced.

4 ADDITIONAL RESULTS

This section reviews some of the most important extensions of the benchmark theoretical framework and discusses their empirical support. Due to space limitations, this overview is inevitably very selective, but it includes references to further readings and more comprehensive surveys.

One of the reasons why top firms are so large is that they sell multiple products. These multi-product firms are even rarer than exporters, but they are nonetheless quantitatively very important. For example, Bernard et al. (2018) show that US firms exporting more than ten (HS10) products represent just 8.4% of all exporters but account for 83.9% of total export value. Although the benchmark model identifies firms with products, it can be extended to include multiproduct firms. A simple way to do so, proposed by Bernard, Redding and Schott (2011), is to interpret the I sectors in equation (1) as different products, such as cars or computers, each available in differentiated varieties ω that are produced by competing firms. Upon entry, a firm draws a single productivity φ , which applies to any product line, and a set of "product attributes" γ_i , one for each product line.

Following the logic of the basic model, a firm finds it profitable to sell product i as long as $\varphi\gamma_i$ is sufficiently high. Hence, firms select not only the markets to serve, but also the products to sell. The extended model implies that more productive firms enter more destinations and sell more products, which is precisely what is observed in the data. Moreover, the selection effect now operates also within firms, in that more competition induces firms to drop their marginal products. Bernard, Redding and Schott (2011) also provide evidence in support of this mechanism. They show that firms that were more exposed to the tariff cuts induced by the Canada–US Free Trade Agreement reduced their products relative to less exposed firms. Similarly, Mayer, Melitz and Ottaviano (2014, 2021) find evidence of the pro-competitive effect at work within firms. Using French data, they find that tougher competition and demand shocks in an export market induced firms to skew their export sales toward their best-performing products.

Besides export decisions and the product mix, trade opportunities can also affect the import behavior of firms. Recent work using firm-level transaction data has shown that the majority of trade is between firms and that importing firms display similar features as exporting firms. For instance, Bernard et al. (2018) report that importers are relatively rare, accounting for around 20% of US manufacturing firms in 2007. As in the case of exporters, importing firms are also larger and more productive than other firms. Moreover, export and import activities tend to be positively correlated: 41% of exporters also import, and 79% of importers also export. To rationalize these findings, Bernard et al. (2018) assume that firms must incur a fixed sourcing cost to be able to import intermediate inputs from a foreign

country. These inputs are also subject to an iceberg variable trade costs.¹⁴ As a result, only the most productive firms find it profitable to pay the import cost. Moreover, this yields a magnification effect: as access to foreign inputs makes firms more productive, importers grow larger in size and may find it profitable to enter more export markets. Bernard and Moxnes (2018) provide a survey of the recent literature on firm-to-firm trade.

Another striking feature of international markets is the quantitative importance of multinational firms. For instance, about 90% of US exports and imports flow through multinational firms, with almost one-half of US imports taking place within multinationals (Bernard et al., 2009). Compared to other exporting firms, multinationals are even larger and more productive. Multinationals can be introduced into the benchmark model of trade with heterogeneous firms in various ways. Helpman, Melitz and Yeaple (2004) allow firms to serve the foreign market through local production by a subsidiary rather than through exporting. The assumption that the fixed cost of opening a foreign subsidiary is higher than the fixed cost of exporting yields a proximity-concentration tradeoff: by producing locally, multinational firms save on the variable trade costs, but must incur the higher fixed cost of running multiple plants. Since the variable-cost saving of multinational production increases with the volume of sales, only the most productive firms find it profitable to open subsidiaries. The predictions of the model are borne out in the data. Specifically, Helpman, Melitz and Yeaple (2004) find that sales by foreign subsidiaries of US multinationals, relative to exports, are higher in sectors with higher trade costs, lower plant-level fixed costs, and a higher dispersion in sales, which indicates a larger proportion of bigger firms.

Firms replicating the production process in different countries so as to save on transport costs are called "horizontal" multinationals. However, firms may also locate different stages of the production process across countries to take advantage of cost differences. These firms are called "vertical" multinationals. To allow for this possibility, Antras and Helpman (2004) assume that production requires an input that can be sourced either domestically or from a low-wage country. Moreover, foreign inputs can be bought from an independent supplier ("outsourcing") or from a subsidiary ("multinational production"). In equilibrium, firms choose the model of operation by comparing their variable and fixed costs, and differences in productivity map into alternative organizational choices. As long as multinational production faces the highest fixed cost (due to the need of opening subsidiaries in foreign countries), but the lowest variable cost (due to lower wages and contractual frictions), it is chosen by the most productive firms. An excellent survey of these theories is provided by Antras and Yeaple (2014).

Finally, these models are well-suited to study the determinants of industrial concentration.

¹⁴Amiti and Davis (2012) and Kasahara and Lapham (2013) were among the first to introduce a fixed cost of importing.

In particular, they can help to shed light on how globalization has contributed to the recent phenomenon of the rise of superstar firms. While it is understood that giant companies such as Apple could not have reached their size without a global market, the exact role of international trade is debated.¹⁵ The models discussed in this article suggest that one reason for concentration is that the margins of firm participation in international markets are systematically correlated with one another. For example, as shown in Bernard et al. (2018), large firms export to more markets, export more products, export more of each product to each market, import from more countries, import more inputs, import more of each input, and so on. Yet, all these models show how exogenous differences in firm attributes, coupled with trade opportunities, yield the endogenous distributions of firm size and sales that are observed in the data. They do not study how differences in attributes arise in the first place.

A recent line of research investigates the possible origins of firm heterogeneity and how it interacts with trade, focusing the attention on the innovation process. In models of firm dynamics such as König, Lorenz and Zilibotti (2016) and Benhabib, Perla and Tonetti (2017), the productivity distribution is the resultant of the endogenous decision to invest in costly innovation or adoption. Innovation stretches the distribution, while adoption compresses it. In Bonfiglioli, Crinò and Gancia (2018), firms can endogenously decide to invest in larger and riskier innovation projects, which generate more heterogeneity. Interestingly, in both cases, trade can change the productivity distribution. The key intuition is that export opportunities, by shifting expected profits to the tail, increase the reward to investing in innovation (Perla, Tonetti and Waugh, 2021) and in riskier projects (Bonfiglioli, Crinò and Gancia, 2018). Consistently, Bonfiglioli, Crinò and Gancia (2019) find that the dispersion in sales across products is positively correlated with measures of comparative advantage in a large panel of countries and industries.

5 CONCLUSIONS AND FUTURE DIRECTIONS

This article has reviewed recent research studying the role of firms in international trade. The development of theoretical models has followed closely the discovery of new empirical facts made possible by the availability of ever more detailed micro data about the operation of firms in international markets. This process is likely to continue. The literature has so far been successful at explaining why only a minority of firms engage in international trade, why they differ from other firms, what are the firm-level margins of adjustment, and how trade reallocates resources towards the most productive firms. This rich apparatus provides a natural framework for studying a broad set of questions, from economic development to industrial and trade policy.

¹⁵See Alessandria, Arkolakis and Ruhl (2021) for a survey of the literature that studies the dynamics of firms in foreign markets.

Yet, a number of open challenges still remain. Among these, three appear of particular relevance. First, while the quantitative importance of top firms is undisputed, there is still a limited understanding on how they emerge in the first place. Second, while reallocations towards these top firms can be the result of an efficient process of growth and specialization, there is also a concern that it may lead to excessive concentration or that it may be the outcome of anti-competitive practices. Third, heterogeneous firms often interact in complex production networks whose consequences and formation are still poorly understood. Investigating these questions is an important direction for future research.

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