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Firm Heterogeneity and International Trade: Implications for Agricultural and Food Industries

by
Munisamy Gopinath*
Ian Sheldon
Rodrigo Echeverria

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Gopinath is Professor in the Department of Agricultural and Resource Economics, Oregon State University, Corvallis, Oregon. Sheldon is Andersons Professor of International Trade in the Department of Agricultural, Environmental and Development Economics, Ohio State University, Columbus, Ohio. Echeverria is Assistant Professor in the College of Agriculture, Universidad Austral de Chile, Valdivia, Chile. The authors thank Jun Ruan for helpful comments on an earlier version of the paper.

*Corresponding author. E-mail: m.gopinath@oregonstate.edu, Phone: 541-737-1402, Fax: 541-737-2563.

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Executive Summary

This article summarizes key insights from the firm heterogeneity and trade literature, the theme-day topic of the 2006 IATRC Annual Meeting, and draws their implications for the agricultural and food industries.

The assumption of homogeneous and symmetric firms in traditional and new trade models is not consistent with recent empirical evidence on firm heterogeneity within an industry. Heterogeneity, observed as firms' differences in productivity, size, and capital and skill intensity, plays an important role in firms' participation in global markets, e.g., the export decision. In addition, exporters are found in comparative disadvantage industries and likewise, importers exist in comparative advantage industries of a country. These empirical facts have led to advances in trade theory, which provide new insights into the causes of trade and consequences of trade reform in the presence of firm heterogeneity. The heterogeneous-firms models suggest that the dispersion of firm productivity within an industry is a new source of comparative advantage. In particular, the larger the dispersion of firm productivity with an industry, the greater is the probability that a proportion of firms export. Another key insight from including firm heterogeneity in trade models is that resource reallocation occurs within an industry due to trade liberalization. That is, both the number of exporting firms and volume of exports change following trade liberalization, referred to as the extensive and intensive margins respectively. Trade-liberalization induced changes in the extensive margin lead to an increase in average industry productivity. The additional gains to a country's (global) welfare from higher within-industry productivity remain a central focus of current empirical and theoretical research.

Food manufacturing is a key component of many studies on firm heterogeneity and trade. The observed differences in productivity, size and skill intensity between exporters and non-exporters in manufacturing industries carry over to food processing firms. However, the applicability of the new firm-heterogeneity models to primary agriculture is not clear since most farms do not export. While most farmers do not know whether or not their respective farm products have been exported, they do know which of their country's products are exported or imported. It may not be the same as the export decision in manufacturing industries, but there is an underlying export-production decision in agriculture. Do farms consciously engage in production of exports and if so, what are the contributing factors to the export-production decision? This question is relevant since an understanding of factors encouraging export production can alleviate structural-adjustment concerns of trade liberalization and make open-market policies politically feasible. A Chilean example demonstrates the existence of heterogeneity, especially in terms of productivity differences, among agricultural producers. Furthermore, productivity dispersion is positively associated with the export-production decision in agriculture. In Chile and the rest of the world, the successful transformation of protected regimes into free-market based agricultural economies appears to critically hinge on productivity improvements at the farm level.

Firm Heterogeneity and International Trade:

Implications for Agricultural and Food Industries

I. Introduction

Why do some firms decide to export or invest abroad while others produce for domestic markets? This question, popularly termed the export decision, has been extensively addressed in the context of manufacturing industries beginning with the seminal contribution of Bernard and Jensen (1995). The emerging theoretical and empirical literature on factors that underlie a firm's decision to export/import, continue to export/import or exit a foreign market have improved our understanding of characteristics of firms participating in global markets (Aw and Hwang, 1995; Aitken, Hanson and Harrison, 1997; Bernard and Jensen, 1997, 1999; Roberts and Tybout, 1997; Clerides, Lach and Tybout, 1998; Girma, Greenaway and Kneller, 2004). To date, the accumulated empirical evidence indicates exporting firms are rare (Bernard *et al*., 2006). For instance, only 4 percent of the 5.5 million U.S firms exported in 2000. Only high-productivity firms self-select into export markets and exporters survive longer and pay higher wages relative to non-exporters in developed and developing economies (Tybout, 2004; Helpman, 2006). However, some gaps remain in this emerging literature on firms' trade participation. The evidence, as of now, on whether exporting improves productivity, i.e., learning-by-exporting, remains mixed (Greenaway and Kneller, 2007). Additionally, the depth and breadth of research on the export decision has not carried over to the import side, until recently (Bernard *et al*., 2006).

Incorporating firm heterogeneity, in terms of productivity differences, into

international trade models has led to two new insights. The first is the addition to the sources of comparative advantage. While Ricardian trade models rely on differences in labor productivity across sectors or industries, the heterogeneous-firms models suggest that the dispersion of firm productivity within an industry is a new source of comparative advantage. In fact, the larger is the dispersion of firm productivity with an industry, the greater is the probability that a proportion of firms export (Helpman, 2006; Helpman, Melitz and Yeaple, 2004). The second insight from including firm heterogeneity in trade models is that resource reallocation occurs within an industry as a result of trade liberalization (Melitz, 2003; Bernard *et al*., 2003; Helpman, 2006). For example, both the number of firms and volume of exports change following trade liberalization, referred to as the extensive and intensive margins respectively. The shift in focus from countries and industries to firms and plants shows that trade reform leads to intra-industry resource reallocation from low- to high-productivity firms. Consequently, an industry's average productivity increases due to the intra-industry "churning" of resources, which is the missing microeconomic basis for the export-led growth phenomenon (Frankel and Romer, 1999; Giles and Williams, 2000; Bernard *et al*., 2006). Thus, the recent general equilibrium models with firm heterogeneity have contributed to a better understanding of the impacts of trade policies such as liberalization and export promotion.

The export behavior modeled in the context of the manufacturing sector directly applies to food manufacturing firms and industries. Indeed, some of the above studies have documented export behavior in food manufacturing (Bernard *et al*., 2006; Roberts and Tybout, 1997). The case of primary agriculture is unique since farmers often do not export and marketing firms make the export decision. However, farmers decide on

producing goods where the export intensity (share of exports in domestic production) is either larger or smaller (Pavcnik, 2002). Why is the export decision or behavior of firms important in the agricultural and food industries? Largely because agriculture remains as one of the highly protected segments of both developed and developing economies, and also because attempts to bring about successful liberalization of the agricultural sector have often been countered with structural-adjustment concerns (Aksoy and Beghin, 2005). Most studies of agricultural trade liberalization claim long-run benefits to reform, but cite significant structural adjustment and the short- to medium-term harm to farm and rural communities. These studies do not model firm or farm heterogeneity, which is a significant factor in the structural adjustment process from a protected regime to a market-based economy, i.e., the intra-industry reallocation of resources noted earlier. Understanding farm and food firms' global market participation would aid in creating successful exporters and making liberalized and open-market policies politically feasible. As empirical evidence shows, successful exporters could bring about stable job and income growth to the specific industry and the broader economy.

The purpose of this article is to: (i) summarize and review the firm heterogeneity and trade literature, the theme-day topic of the 2006 Annual Meeting of the International Agricultural Trade Research Consortium (IATRC); and (ii) draw the implications of this emerging literature for agricultural and food industries.[1] In the next few sections, the key arguments of the firm heterogeneity and trade literature are surveyed including those presented at the 2006 IATRC Annual Meeting. In the final two sections of the article, applicability of these arguments to the case of the agricultural and food industries is

[1] See the appendix for a list of articles presented and presenters at the 2006 IATRC Annual Meeting.

shown, and some of the initial attempts at application to these industries are reviewed. Policy implications are noted in the final section with a summary and conclusion.

II. The Empirical Beginning: Self-Selection and Learning-by-Exporting

Beginning with the contribution of Bernard and Jensen (1995) and Aw and Hwang (1995), an extensive field of empirical trade research using firm-level data has emerged. In the U.S. manufacturing sector, Bernard and Jensen (1995) found that exporting firms are larger, more productive, more skill and capital-intensive, and pay higher wages than the non-exporters (see also, Bernard *et al*., 2006). Using firm-level data from the Taiwanese electronic industry, Aw and Hwang (1995) found that export-oriented firms had higher productivity levels relative to those serving only domestic markets. Recent research has concentrated on evidence of the differences between exporters and non-exporters and the causes that lead to exporters' higher productivity. A complete survey of the firm-level literature can be found in Tybout (2004), Greenaway and Kneller (2007) and Helpman (2006). Additionally, this literature has addressed the differences between exporters and firms that invest abroad based on the proximity-concentration tradeoff, originally due to Brainard (1997). For instance, Helpman, Melitz and Yeaple (2004) find that U.S. multinationals enjoy a 15 percent labor-productivity advantage over firms that only export.

Two hypotheses have been proposed to explain the higher productivity of exporters relative to other firms. The first hypothesis is based on a self-selection process by firms themselves. Exporting requires extra resources in the form of transportation, distribution and marketing costs, workers with foreign managerial skills, and

modification of domestic products for external markets. These costs impose a barrier that only the more productive firms can afford (Bernard and Jensen, 2004; Basile, 2001; Wakelin, 1998). Hence, only high-productivity firms can afford these costs, making firms self-select into export markets. Evidence supporting this hypothesis can be found in Bernard and Jensen (1999) for the U.S.; Clerides, Lach and Tybout (1998) for Colombia, Mexico and Morocco; Aw, Chung, and Roberts (2000) in Korea and Taiwan; Alvarez and Lopez (2004) in Chile; Girma, Greenaway and Kneller (2004) in the UK; and Delgado, Farinas and Ruano (2002) in Spain.

The second hypothesis is based on the idea that firms can improve their productivity by capturing knowledge and technical spillovers from their participation in international markets. Exporters are exposed to demanding buyers who require improved production and marketing processes. Besides, the contact with high quality buyers gives firms an opportunity to improve their productivity. Hence, firms undergo a learning-by-exporting process which can lead to higher productivity relative to those producing only for the domestic market. However, evidence supporting this hypothesis is mixed. Some studies show that there is a positive effect of exporting on productivity, but this effect is insignificant when compared to that of self-selection (Clerides, Lach and Tybout, 1998; Aw, Chung and Roberts, 2000).

In addition to productivity, the role of sunk-entry/exit costs has figured prominently in the export-decision literature. Roberts and Tybout (1997) using a dynamic, firm-level model showed that the significant role of sunk entry- or exit-costs on Colombian firms' decision to export. Following that study, the search for the sources of sunk-entry/exit costs has focused on exchange rates, trade policies and agglomeration

economies (Krugman, 1991; Fujita, Krugman and Venables, 1999; Alonso-Villar, Chamorro-Rivas and Gonzalez-Cerdeira, 2004; Greenaway and Kneller, 2007). Despite the mixed evidence for exchange-rate effects on aggregate trade, micro studies suggest that changes in exchange rates are more likely to lead to changes in the intensive rather than extensive margin. Documenting the dollar depreciation episode of the 1980s, Bernard and Jensen (2004) report that 87 percent of export growth is from increased export intensity of current exporters, while the rest was attributed to new exporters. On trade policies, the impact of liberalization and export promotion on the number of exporters and the volume of export has received some attention in this literature. For instance, Baldwin and Gu (2004) find that the North American Free Trade Agreement (NAFTA) increased the intensive and extensive margin among Canadian firms, but the latter effect is stronger. That is, NAFTA increased the probability that a firm exports by 63 percent. The evidence on the effect of agglomeration on exports (entry and intensity) appears limited. Some evidence of knowledge spillovers among exporters as a determinant of export entry and volume can be found in Aitken, Hanson and Harrison (1997) and Clerides, Lach and Tybout (1998). For a more recent study, see Greenaway and Kneller (2007).

The extensive empirical literature on the export decision confirms firm heterogeneity in several dimensions: productivity, size, and labor, skill and capital-intensity. Key factors determining a firm's decision to export are sunk-entry/exit costs and productivity. These results from micro studies using firm- or plant-level data have challenged the traditional and new-trade theories. Homogeneity of firms within an industry is assumed in the Ricardian and Heckscher-Ohlin models (and their extensions),

where comparative advantage in an industry means all firms in that industry export equal shares of their production to foreign markets. While the new trade models based on Krugman (1980) have an explicit role for firms, the monopolistically competitive equilibrium is only solved for the case of symmetric firms, i.e., every firm has the same technology and hence market share. The empirical evidence reviewed above has led to new trade models incorporating firm heterogeneity, the key theme of the next section.

III. Theory Follows Empirical Evidence: A New Source of Trade?

The newer international trade models with firm heterogeneity can be broadly classified into two types: extensions of the Ricardian model as in Bernard *et al*. (2003) and of Krugman's monopolistic competition model as in Melitz (2003). Other improvements to theory along these two lines include Bernard, Redding and Schott (2007), Helpman Melitz and Yeaple (2004), Eaton, Kortum and Kramarz (2005), Yeaple (2005). Among these models, Melitz (2003) is analytically tractable and easily offers opportunities for extensions. The following discussion draws on Melitz (2003) and Helpman, Melitz and Yeaple (2004) in order to illustrate the emerging conceptualization of firm heterogeneity and trade.

There are N countries indexed by i, each of which uses labor to produce goods in $H+1$ sectors. One sector produces a homogeneous good, while H sectors produce differentiated products. Consumer preferences are of the Dixit-Stiglitz (1977), love-of variety, type with an elasticity of substitution (ε) greater than 1. Consumers spend an exogenous fraction of income $\beta_h \quad (h = 1, 2, ..., H)$ on the differentiated products of each sector h and the expenditure share of a homogeneous good is $(1 - \sum_h \beta_h)$. Given

preferences and the budget constraint, demand for each variety takes the form $A^i p^{-\varepsilon}$, where A^i is the *i*-th country's demand level and *p* is the price of a particular brand offered for sale.

The production side of the model is similar to that of Krugman's (1980) one-factor (labor) setting. Each country is endowed with L^i units of labor and its wage rate is w^i. For notational convenience, we avoid the subscript for sectors (*h*). To enter any sector or industry, a firm must incur a fixed cost, expressed in units of labor, f_E. Upon entry, the firm draws its labor-per-unit-output coefficient (*a*) from a distribution *G(a)*. With any given *a*, the firm has four choices as illustrated in figure 1. A firm exits, if revenue based on its *a* cannot cover additional fixed cost of production, f_D. Given a country's demand and the firm's realization of *a*, operating profits are $\pi_D^i = a^{1-\varepsilon} B^i - f_D$, where B^i is a monotonic function of the demand level A^i.

Firms may serve foreign markets via exports or FDI, where the choice is driven by the proximity-concentration tradeoff (Brainard, 1997). Exporting requires an additional fixed cost f_X, while setting up a foreign production facility costs f_I, where $f_I > f_X$.[2] Furthermore, firms incur iceberg trade cost, $\tau^{ij} > 1$, when shipping from country *i* to *j*. Additional operating profits from exporting and FDI are respectively, $\pi_X^{ij} = (\tau^{ij} a)^{1-\varepsilon} B^j - f_X$ and $\pi_I^{ij} = a^{1-\varepsilon} B^j - f_I$. As figure 1 shows, when a firm's additional

[2] See Helpman, Melitz and Yeaple (2004) for a weaker condition than $f_I > f_X$.

revenue from exporting to or investing in country *j* can cover respective fixed costs ($f_D + f_X$ or $f_D + f_I$), it either exports or invests abroad.[3]

When countries *i* and *j* are similar in demand level, labor endowment and wages, the three operating profit functions can be depicted as in figure 2, taken from Helpman, Melitz and Yeaple (2004). Since the elasticity of substitution is greater than 1, $a^{1-\varepsilon}$ is interpreted as productivity, i.e., increases in output per unit of input. Along the X-axis, productivity increases, while profits are plotted on the Y-axis. Note that the domestic-sales profit function and the additional profit from investment abroad are parallel since demand levels are assumed to be the same in countries *i* and *j*. Since revenues from exporting are scaled by trade costs, the additional profit function from exporting is less steep than the other two. These profit functions define three cut-offs, one each for firms to serve domestic markets, export and invest abroad. Firms that draw a labor-per-unit-output coefficient such that their productivity $a^{1-\varepsilon}$ is below $a_D^{1-\varepsilon}$ will exit, while those draws between $a_D^{1-\varepsilon}$ and $a_X^{1-\varepsilon}$ will lead to firms serving only the domestic market. When a firm obtains a productivity draw above $a_X^{1-\varepsilon}$, but below $a_I^{1-\varepsilon}$ it switches from domestic markets to exports. Likewise, a productivity realization above $a_I^{1-\varepsilon}$ leads a firm to set up overseas production.

Given the consumption and production setting as described above, equilibrium in the model hinges critically on the three cut-off productivity levels. Free entry of firms and zero profit conditions in each sales category -domestic, export and overseas

[3] In this setting, a firm does not export and invest abroad. See Rob and Vettas (2003) for a treatment of firms' decision to simultaneously export and invest abroad.

production- determine $a_D^{1-\varepsilon}$, $a_X^{1-\varepsilon}$, and $a_I^{1-\varepsilon}$ and the demand levels in each country. Some general equilibrium results include:

- Larger countries attract a disproportionately larger number of entrants and a larger number of sellers. Hence, welfare per worker in a larger country is higher due to increased product variety.
- Larger markets are disproportionately served by domestically-owned firms, i.e., the market share of domestically-owned firms is larger in the home market of a larger country.[4]
- All countries share the same cut-offs in each sales category so long as countries do not differ too much in size, and wages are the same everywhere.
- Industry average productivity and average profits are endogenously determined and affected by changes in trade costs. Alternatively, average industry productivity increases with falling trade costs. This result does not diminish the productivity-augmenting role of research and development, which likely impact the distribution of productivity, *G(a)*, and a firm's likelihood of drawing a higher productivity level.

The last of the above bullets has provided a crucial link missing in the earlier literature, especially that on export-led growth ideas (Giles and Williams, 2000). One of the key insights from the firm heterogeneity and trade literature is the formal link between trade costs and intra-industry (or inter-firm) reallocation of resources. Naturally, these newer trade models have to rederive the welfare effects of trade reform, which should consider

[4] This result is similar to the home-market effect of Krugman (1980).

not only inter-industry but also intra-industry reallocation of resources with a focus on firms and plants.

IV. Welfare Effects of Trade Reform in the Presence of Firm Heterogeneity

To derive the welfare effects of trade reform in the context of heterogeneous firms, consider figure 2 again. Regardless of export or import sectors (comparative advantage or disadvantage industries), firms' decision to participate in domestic and foreign markets critically depends on its productivity realization, sunk costs in each entry mode and trade costs as shown by the empirical studies. In other words, even if a country has comparative disadvantage in an industry, some of its firms may export and produce overseas depending on the dispersion of productivity. For example, Bernard *et al*. (2006) report that 27 percent of U.S. textile plants, a comparative disadvantage industry due to its unskilled labor intensity, exported on average 14 percent of their output in 2002. In this section, the welfare effects of trade liberalization are discussed as if figure 2 first applies to an import sector, followed by the case of an export industry.

Recall that firms entering the industry incur a fixed, entry cost and then draw a labor-per-unit-output coefficient denoted by a. Based on the productivity realization, firms choose one of the following: (i) exit, (ii) to serve domestic markets, (iii) export, and (iv) invest overseas. With our initial focus on import sectors, assume that prices in the home market are higher due to a trade barrier. Productivity cut-offs $a_X^{1-\varepsilon}$ and $a_I^{1-\varepsilon}$ are not affected by the presence of a trade barrier. That is, when firms realize higher productivity coefficients, they serve only the foreign market via exports or FDI. However, the productivity cut-off for firms serving only the domestic market, $a_D^{1-\varepsilon}$,

would be affected by the presence of a trade barrier. The operating profit for firms serving only the domestic market would be higher inducing π_D^i to rotate to the left.[5] More firms would be break-even (zero profit) with a trade barrier than otherwise. Let $\left(a_D^{1-\varepsilon}\right)^* < a_D^{1-\varepsilon}$ define the equilibrium productivity cut-off for firms serving only the domestic market in the presence of a trade barrier.

With trade liberalization by the home country, the productivity cut-off for domestic-market firms would increase to $a_D^{1-\varepsilon}$ bringing about domestic firm death, lower industry prices and higher average industry productivity. Firm-level empirical studies surveyed in Helpman (2006) and Tybout (2000, 2004) show such effects, but the literature on the welfare effects of trade liberalization has not formally established either firm death or the productivity effect. As Melitz (2003) shows, higher average industry productivity is directly related to welfare per worker in the home country.

Now reconsider figure 2 for the case of an export sector. As before, firms with productivity coefficients between $a_D^{1-\varepsilon}$ and $a_X^{1-\varepsilon}$ serve only domestic markets, while those between $a_X^{1-\varepsilon}$ and $a_I^{1-\varepsilon}$ export to foreign markets. Firms investing overseas for production have productivity coefficients above $a_I^{1-\varepsilon}$. Foreign country's trade costs, including transport costs and trade barriers, positively affect the export cut-off, $a_X^{1-\varepsilon}$. As trade costs decline, more firms with productivity coefficients just below $a_X^{1-\varepsilon}$ find it (zero) profitable to export. So, many firms that served only domestic markets will now become exporters as the export productivity cut-off shifts to the left. Trade liberalization increases export participation and volume (extensive and intensive margins) and also

[5] Note that the fixed production costs, f_D, do not change in this illustration.

results in higher average industry productivity due to the turnover of firms from domestic to export markets. These results are consistent with empirical evidence from micro studies of firm behavior, but prior studies on trade liberalization have mostly focused on intensive margins with *ad hoc* links to average industry productivity and without firm birth or death.

V. Applications to Food Manufacturing

How applicable are the new firm heterogeneity models to food and agricultural industries? Food processing firms are a key constituent of the manufacturing sector. In some countries, e.g., Chile, Colombia, food processing accounts for a major share of the manufacturing sector. Several studies cited in the previous sections have documented food manufacturing firms' behavior including their export decision (Bernard *et al*., 2006; Tybout, 2000; Bernard and Jensen, 1995).

Using data from 1987, Bernard and Jensen (1996) found that about 13 percent of U.S. food manufacturing plants exported on average 5 percent of their shipments. The comparable statistics for aggregate manufacturing are 15 and 10 percent, respectively. Table 1a, based on Bernard *et al*. (2006), presents similar statistics for 2002, but based on the new industrial classification system, NAICS. In 2002, 15 percent of the food-manufacturing plants exported on average 15 percent of their shipments, while the respective indicators for aggregate manufacturing are 20 and 15 percent. Between 1987 and 2002, it appears that the share of exporting plants in U.S. food manufacturing increased marginally, but the intensive margin, i.e., export share of shipments, tripled. Furthermore, about 5 percent of U.S. food manufacturing firms export as well as import

(table 1b). Few studies report export participation statistics in the food industries of developing countries. Exceptions include studies by Roberts and Tybout (1997) for Colombia, and Echeverria (2006) for Chile. The latter's finding that exporting is rare (extensive margin) is consistent with that of Bernard *et al*. (2006).

Food firms, similar to their manufacturing counterparts, exhibit heterogeneity in terms of productivity, plant size, and capital and skill intensity (Bernard *et al*., 2006; Tybout, 2000; Echeverria, 2006). For instance, exporters in U.S. food manufacturing are relatively more capital and skill-intensive than those in aggregate manufacturing. Roberts and Tybout's (1997) sample of Colombian firms includes a substantial number of food manufacturing firms. Echeverria (2006) finds significant size and capital and skill-intensity differences between exporters and non-exporters in Chilean food manufacturing.

Firm heterogeneity in the productivity dimension has received considerable analytical attention in developed and developing economies. Surveying firm-level productivity studies, Tybout (2000, 2004) finds higher average industry productivity in developed relative to developing economies, but there is mixed evidence on whether productivity dispersion is greater in the latter countries. A number of studies in Tybout's (2000) review have focused on productivity level and dispersion in the food manufacturing industries. Pavcnik (2002) derives plant-level productivity measures for the case of Chilean food processing plants during 1979-1986 using the Olley and Pakes (1996) technique. She finds significant evidence of productivity dispersion in most manufacturing industries. Echeverria (2006) uses a deterministic frontier approach and more recent data (1999-2003) to derive plant-level total factor productivity in Chilean food manufacturing. Although he found mixed evidence on productivity differences

between exporters and non-exporters, Echeverria (2006) reports that the export decision of Chilean food firms is strongly affected by sunk-costs and foreign ownership of production facilities.

It appears that firm heterogeneity in food manufacturing is similar to that in aggregate manufacturing. However, few studies have explored their role in export behavior, i.e., self-selection and learning-by-exporting ideas, of the food manufacturing industries. As in the case of manufacturing industries, food firms report overseas sales, but do not provide sourcing and/or contracting strategies used in such sales (Helpman, 2006; Morrison Paul and Yasar, 2006). In other words, there is less clarity on the various stages involved in shipping from either home to foreign markets or in overseas production. Hence, it is not clear to what extent food manufacturing firms' decision to participate in domestic and foreign markets depend on their productivity dispersion, and sunk and trade costs. Depending on the strength of that relationship, the effects of trade liberalization should include intra-industry reallocation of resources and the gains from higher average industry productivity. The churning of resources within the food manufacturing sector implies exit of low-productivity firms, but under the assumption of single-product firms or plants. Food manufacturing firms or plants often produce multiple products. Moreover, significant economies of scope exist in food manufacturing, which can mitigate some of the welfare losses associated with the exit of firms and resource reallocation (Morrison Paul, 2001).

VI. Implications for Primary Agriculture with a Chilean Example

Can the firm-heterogeneity models help understand farmers' export behavior, and

provide additional insights into structural adjustment and welfare to guide agricultural trade policies? The first hurdle in answering this question is that farmers most often do not export. Agriculture is somewhat unique where marketing firms make the export decision. Unlike manufacturing firms, farms cannot record domestic and foreign sales since they do not have information on their product after it leaves the farm gate. Furthermore, reported foreign direct investment statistics in agriculture, which uses land intensively, account for a negligible share of overall global capital flows (UNCTAD, 2005). The lower degree of clarity on who actually exports agricultural goods, however, does not make the important farm-level decision on market participation non-significant.[6] Owners and operators of farms in developed and developing countries have access to information on their respective agricultural exports and imports. With that information, farms decide on producing more or less export-intensive commodities, i.e., larger or smaller share of exports in domestic production (Pavcnik, 2002). It may not be the same as the export decision in manufacturing industries, but there is an underlying export-production decision in agriculture. Do farms consciously engage in production of exportable goods and if so, what are contributing factors to the export-production decision? Alternatively, why are farms' export-production decisions important? This question is relevant given the high level of protection of agriculture in developed and developing economies based on structural-adjustment and political concerns (Aksoy and Beghin, 2005). An understanding of factors encouraging export production can alleviate structural-adjustment concerns of trade liberalization and make open-market policies

[6] The literature on economic development has investigated the market participation of farm households. In many developing countries, these studies have addressed factors determining input or output market participation, its timing and quality (Bellemare and Barrett, 2006; Key, Sadoulet and de Janvry, 2000; Goetz, 1992).

politically feasible.

To illustrate the export-production decision, we draw on a recent contribution by Echeverria (2006) on Chilean farms' export participation. Indeed, Chile is the most cited example of the agricultural export-led growth theory. In Chile, fruits and fruit-derivatives (e.g., wine) have accounted for about 80 percent of Chilean agricultural exports during the last two decades. Moreover, 15 fruits accounted for 93 percent of all fruit exports. The second largest export group is vegetables and flowers accounting for another 11 percent of exports, while traditional agricultural commodities like grains and animal products (e.g., beef) constituted a small share (< 6 percent) of exports. Such sharp trends allow Echeverria (2006) to identify a set of pure-export and pure-traditional producers from the 1997 Chilean Census of Agriculture. That is, none of the pure traditional farms produce an exportable crop and vice versa. In their sample of 8,284 farms, about 73 percent are pure-traditional producers, while the rest are pure-export producers. With farm-level output and input data, Echeverria (2006) applies data envelopment analysis (DEA) to derive total factor productivity (TFP) of these two sets of pure-players. Figure 3 shows the frequency distribution of TFP scores, which take values between 0 and 1, where the latter score for a farm would mean that it is on the efficiency frontier defined by observed data.

The average TFP score of the 8,284 Chilean farms is 0.71 with a standard deviation of 0.23. The pure-exporters' average TFP score is 0.94 with a standard deviation of 0.08, while the corresponding measures for pure-traditional producers is 0.62 and 0.21. Such stark productivity differences between these two groups, is consistent with the export-decision literature (Bernard *et al*., 2006; Helpman, 2006). It appears that

high-productivity Chilean farms engage in exportable production. Furthermore, the pure-exporters more often had a manager on farm, employed more unskilled labor, and higher educational level (owner or manager) relative to producers of traditional commodities (Echeverria, 2006).

In contrast to manufacturing firms, geographic characteristics may play an important role in farms' export-production decision (Fujita, Krugman and Venables, 1999; Greenaway and Kneller, 2007). Natural advantage, e.g., soil type, agronomic conditions and climate, has figured prominently in the crop-portfolio choice literature (Gardner, 2002; Chavas and Holt, 1990). Echeverria (2006) addresses the relative importance of firm-specific and geographic characteristics in the export-production decision of Chilean farms. In addition to the most commonly used geographic characteristics such as infrastructure, human capital and government quality, they use regional soil quality to represent natural advantage. Using a discrete choice model, as in Aitken, Hanson and Harrison (1997), Echeverria (2006) finds that farm TFP, presence of skilled labor on farm, regional human capital, and government quality are key factors positively affecting Chilean farms' export-production decision. Based on the magnitude of predicted probabilities they report that farm-TFP effects appear relatively stronger than the combined effects of geographic characteristics on the export-production decision. When a high-productivity farm locates in a region with better geographic characteristics, its likelihood of producing exports is higher. On the other hand, opposite results are obtained when low-productivity farms are located in regions with higher human capital or government quality. The latter is due to an efficiency threshold for farms to participate in export production.

The Chilean example demonstrates the existence of heterogeneity, especially in terms of productivity and skill differences, among agricultural producers. Furthermore, productivity dispersion is positively associated with the export-production decision in agriculture. Geographic characteristics are important, but they seem to affect export-production probability only if farms achieve a minimum productivity threshold. Further liberalization of Chilean agriculture, e.g., lowering the uniform tariff of 36 or 11 percent on traditional commodities, would likely bring about a intra-industry churning of resources favoring export production. The transformation of southern Chilean regions from traditional producers (protected regime) into exporters (free market regime) critically depends on productivity improvements at the farm level.

VII. Summary and Conclusions

The purpose of this article is to identify key insights from the firm heterogeneity and trade literature, the theme-day topic of the 2006 IATRC Annual Meeting, and draw implications for the agricultural and food industries.

The role of firms in traditional and new trade models has been limited. The Ricardian and Heckscher-Ohlin models focus on industries or sectors, while the Krugman-type monopolistic competition models assume identical or symmetric firms. However, the empirical evidence shows firms differ not only across but also within industries of a country. These differences, often termed firm heterogeneity, are observed in multiple dimensions: productivity, size, and capital and skill intensity. Furthermore, such heterogeneity is more important for firms' or plants' participation in global markets, e.g., export, import or overseas production. In other words, comparative advantage

(disadvantage) does not mean all firms in an industry export (import). Exporters can be found in comparative disadvantage industries and likewise, importers exist in comparative advantage industries of a country. The emerging literature on firm heterogeneity and trade considers productivity and sunk (entry) costs as some of the key determinants of firms' global market participation, e.g., the export decision. Advances to trade theory have been made incorporating firm heterogeneity, which has led to new insights into welfare gains associated with trade reform. In particular, the effects of trade liberalization on firm birth and death (the extensive margin) and scale of export, imports and FDI (the intensive margin) within an industry have provided a key missing link in the export-led growth theory. That is, following trade liberalization changes in the extensive margin lead to an increase in average industry productivity. These additional gains to a country's (global) welfare from higher within-industry productivity remain a central focus of current empirical and theoretical research.

Food manufacturing is a key component of many studies on firm heterogeneity and trade. The observed differences in productivity, size and skill intensity between exporters and non-exporters in manufacturing industries easily carry over to food processing firms. However, the applicability of the new firm heterogeneity models to primary agriculture is not clear since most farms do not export. While most farmers do not know whether or not their respective farm products have been exported, they do know which of their country's products are exported or imported. It may not be the same as the export decision in manufacturing industries, but there is an underlying export-production decision in agriculture. Do farms consciously engage in production of exports and if so, what are the contributing factors to the export-production decision?

Alternatively, why are farms' export-production decisions important? This question is relevant since an understanding of factors encouraging export production can alleviate structural-adjustment concerns of trade liberalization and make open-market policies politically feasible.

The Chilean example demonstrates the existence of heterogeneity, especially in terms of productivity and skill-intensity differences, among agricultural producers. Furthermore, productivity dispersion is positively associated with the export-production decision in agriculture. Geographic characteristics are important, but they seem to affect export-production probability only if farms achieve a minimum productivity threshold. In Chile and the rest of the world, the successful transformation of protected regimes into free-market based agricultural economies appears to hinge critically on productivity improvements at the farm level.

Table 1a: Plant Export Behavior in Selected U.S. Food and Related Industries, 2002

NAICS Industry	Share of Manufacturing Plants (%)	Share of Exporting Plants (%)	Mean Export Share of Shipments (%)	Mean Capital Intensity ($000)	Mean Skill Intensity (%)
Food Manufacturing	8	15	15	87	33
Beverage and Tobacco	1	21	9	183	48
Textile Mills	1	27	14	92	21
Textile Product Mills	2	14	11	25	25
Wood Product Manufacturing	5	10	17	58	20
Aggregate Manufacturing	100	20	15	77	29

Table 1b: Firm Participation in Global Markets in Selected U.S. Food and Related Industries

NAICS Industry	Share of Manufacturing Firms (%)	Share of Exporting Firms (%)	Share of Importing Firms (%)	Share of Firms that Import and Export (%)
Food Manufacturing	7	12	9	5
Beverage and Tobacco	1	25	17	11
Textile Mills	1	36	27	19
Textile Product Mills	2	12	12	6
Wood Product Manufacturing	5	8	4	2
Aggregate Manufacturing	100	18	11	8

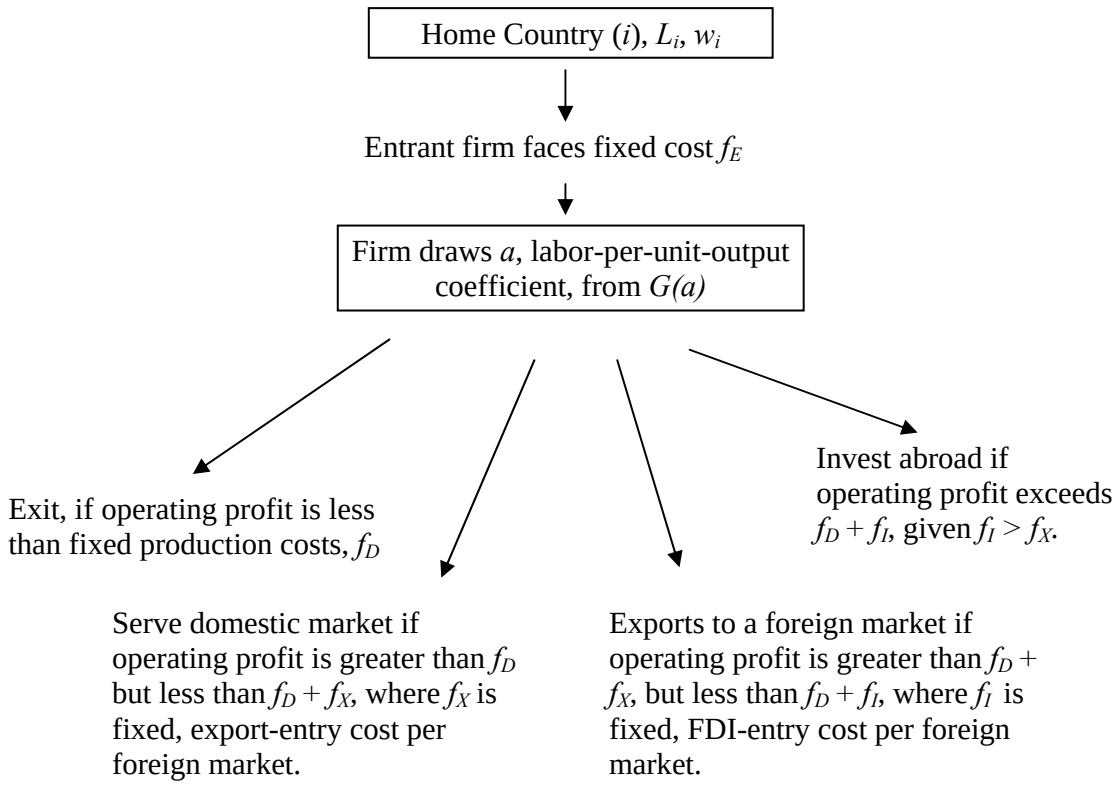


Figure 1: Helpman, Melitz and Yeaple Framework

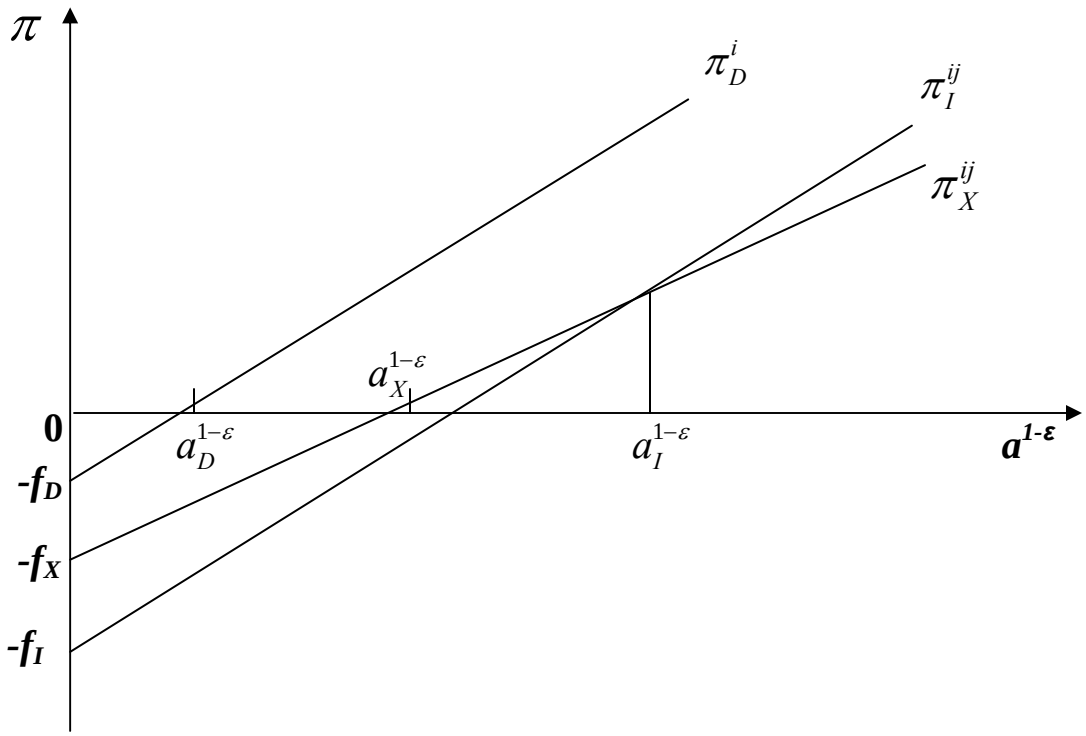
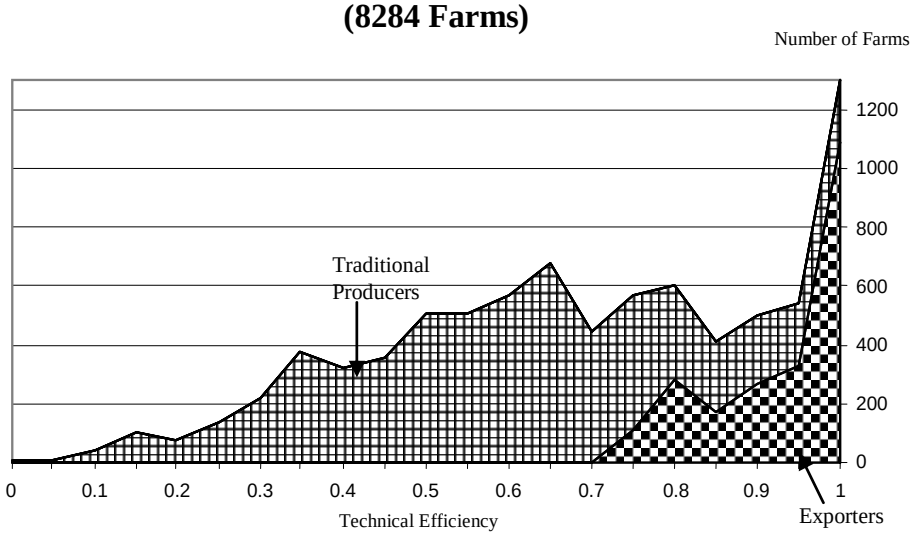


Figure 2: Operating Profits from Domestic Sales, Exports and FDI

Figure 3: Distribution of Chilean Farms According to TFP Scores (8284 Farms)



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Appendix
List of Theme-Day Presentations at the 2006 IATRC Annual Meeting
December 3-5th, St. Petersburg, FL

Bernard, A.B.*, J.B. Jensen, S.J. Redding, and P.K. Schott (2006). "Firms in International Trade." http://mba.tuck.dartmouth.edu/pages/faculty/andrew.bernard/jep.pdf
(Discussant: Thomas Hertel, Purdue University)

Greenaway, D., and R. Kneller* (2005). "Firm Heterogeneity, Exporting, and Foreign Direct Investment." http://www.gep.org.uk/research_papers/05_32.htm
(Discussant: Steve McCorriston, University of Exeter)

Eaton, J., S. Kortum*, and F. Kramarz (2005). "An Anatomy of International Trade: Evidence from French Firms"
http://www.econ.umn.edu/~kortum/papers/ekk1005.pdf
(Discussant: Daniel Sumner, University of California-Davis)

Morrison Paul, C.J.*, and M. Yasar (2006). "Outsourcing, Productivity and Input Composition at the Plant Level" http://www.agecon.ucdavis.edu/
(Discussant: Daniel Pick, Economic Research Service, USDA)

Maskus, K.*, and Y. An (2006). "Sectoral Estimation of the Knowledge Capital Model: Do US Multinational Enterprises in the Food Industry Behave Differently?"
http://spot.colorado.edu/~maskus/research.html
(Discussant: Terry Roe, University of Minnesota)

Discussion Panel Co-Chairs: Edward Schuh, University of Minnesota
Will Martin, The World Bank.

*Presenter