Does the U.S. Trade More Widely Than It Appears?

BY ROC ARMENTER

Trade matters. International commerce accounts for almost one-fifth of the U.S. economy's gross output. And by finding foreign markets for their goods, U.S. manufacturers provide jobs at home — even while competition from cheaper foreign goods may dampen domestic employment. Indeed, it is not a stretch to say that economics as a separate discipline was born from the observations of David Ricardo and Adam Smith on trade. But trade matters beyond its impact on national income. It affects domestic workers and firms that face foreign competition, and as a result, it is a recurrent topic of public discussion.

We often hear stories about some developing country offering a product at half the price of a made-in-America equivalent and sending a domestic industry into disarray and its workers into unemployment. Or politicians debate the fairness and impact of China's trade policy on the U.S. economy. Indeed, China is the perfect example of a country "making the leap" through trade, catching up with the latest technology and being able to compete in global markets. And going further back in time, but much closer in space, the cotton trade was instrumental in the development of the U.S. economy in the 19th century.

Given trade's importance, it is perhaps surprising to learn that most of the products manufactured in the U.S. are actually not traded with the vast majority of countries over the course of a year.[1] For example, the U.S. exports several thousand distinct products to Canada, spanning most of the nearly 9,000 product classifications provided by the U.S. Commerce Department. Yet, the U.S. sells just a few hundred to many other countries. Why would the U.S. sell a product in Germany and not in, say, Poland? Another interesting observation is that few U.S. firms actually engage in exporting. In 2005, less than a fifth of all U.S. manufacturing firms had any foreign sales. Given that the vast majority of manufactured goods can be traded at a relatively low transportation cost, why are so many U.S. firms failing to compete abroad? Are there insurmountable barriers to trade, perhaps some of them man-made? Or is the U.S. manufacturing sector much less competitive abroad than we thought? In other words, what is behind these "missing" trade flows? Economists would like to understand the underlying barriers to trade to be able to answer all these questions.

Several researchers have made substantial progress by documenting strong links between trade and both market size and firm size. First, the U.S. is more likely to trade with larger, closer countries. Second, it tends to sell to these countries products that represent a larger share of its exports. Third, firms that export are also larger, in terms of both revenue and employment, and they appear to be more productive and capable of manufacturing a wide array of products.

These links between trade and size have led economists to posit theories of economies of scale in trade. Economists say that a production technology of a good exhibits economies of scale when the average production cost decreases as total production increases. The basic tenet in firm-level trade models is that firms must incur a large initial cost to begin selling their goods in a foreign market. For example, they may need to set up a distribution network or modify the product to meet the destination country's standards. But as the exporting firm sells more of the product to the importing country, these costs are offset by more sales revenue. Therefore, the bigger the firm, the bigger the production run, and the lower the cost of exporting per individual good sold. Economies of scale theories can explain why small firms, small countries, and low-demand products may not trade.

[1] My discussion will focus on trade in manufactured goods. Of course, services are also traded internationally in the form of travel, royalties, license fees, and so forth. Although the U.S. actually exports more services than it imports, and thus enjoys a small surplus in this category, services remain a relatively small component of total trade compared with goods and raw materials.

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However, as we will see, economies of scale are not adequate to explain certain key aspects of actual international trade flows. For example, it is often the case that a product will be exported to one destination one year and not the next, and then shipped there again the year after that. It is also telling that many actual trade flows are very small in quantity or value, which casts some doubt on whether trade barriers are in fact all that formidable. To help explain these observations, I will instead advance the possibility that the U.S. does export most of its products to most countries — just not very often. It turns out that for many possible trade flows, we should not expect to see trade every year, but perhaps only once every few years. It thus becomes difficult to assert whether a missing trade flow in any one year is indeed a relevant observation. The distinction between missing and infrequent trade is important because the latter implies that the impediments to trade may be substantially smaller than previously thought.

A RICH, QUIRKY TROVE OF DATA

The U.S. collects and makes available detailed data for both imports and exports through the Census Bureau. At the monthly frequency, trade data provide information about each shipment, specifying its total dollar value, the country of origin (for imports) or destination (for exports), and detailed information about the product shipped. This trove has its origins in tariff and duty collection, which, luckily for trade economists, requires detailed data, as the rates typically vary with the type of product and country of origin or destination.

Currently, each product is classified according to the Harmonized System (HS) of unique 10-digit codes. The first two digits indicate the broadest category, known as a chapter (for example, cereals, pharmaceutical products, or beverages); the next two digits provide a more detailed description and so on. For example, a beverage is first classified as water, juice, soda, beer, wine, and so on. Then if the beverage is, say, wine, it is further classified as fermented from grapes or another fruit, as sparkling or not, and finally as red or white.[2] These codes are valuable to trade economists, who often use the 10-digit description to indicate a distinct product. However, we do need to recognize that the classification system was not designed with academic research in mind. Sometimes even a 10-digit classification is covering up a substantial amount of heterogeneity. Take code HS6110110020, which covers the fairly broad category of women's wool sweaters. Meanwhile, other codes introduce quite irrelevant distinctions such as the size of the container. Sometimes products receive very close classifications because they share some physical or production attributes, yet we would never think of having one instead of the other. For example, vinegar is classified with wine as a beverage!

MISSING TRADE FLOWS

The data show that in any given year the U.S. trades a surprisingly narrow range of products with a limited set of destinations — trade being more common with large, nearby countries. To determine to what extent U.S. firms are absent from foreign markets, let us first construct a measure of all possible trade flows. To keep the discussion concise, we focus on U.S. exports in 2002.[3] Take all the products the U.S. sold *somewhere* and all the countries where the U.S. sold *something* in 2002. Combine both to construct all possible product-country pairs; that is, vinegar to Germany is one pair, vinegar to Guatemala another one; women's wool sweaters to Guatemala is yet another.

Which fraction of these possible trade flows did we actually observe in 2002? The surprising answer is very few — less than one-fifth of them! There are about 9,000 active product classifications. Looking at countries, we find that Canada received more than 8,000 different products from the U.S., but half of the countries received fewer than 700 products, and one-quarter of the countries received no more than 150 products.[4]

Looking at products, we find that half of the products were sold to only 35 or fewer countries, and a quarter of them reached 15 countries at most. Since there are questions about the HS classification being the right definition of a product, it is worth asking what happens if we use a broader classification. Table 1 reports the share of missing trade flows among all possible product-country pairs for different classification levels, from 10 digits (the most detailed description) to two digits (the broadest definition). The majority of possible trade flows remain unobserved even when product definitions are lumped together at the four-digit level, encompassing more than 1,000 distinct categories. Even if we distinguish only among broad chapters — there are only about 100 of them — more than one-third of all possible trade flows are missing. Similar results are obtained for imports.

[2] The HS system is maintained by the World Customs Organization, with the first six-digit classification being common across countries. More detailed descriptions are often associated with tariff legislation. A complete guide to the HS system can be found at http://www.usitc.gov/tata/hts/bychapter/index.htm.

[3] This is unfortunately the latest data available at the firm level.

[4] Shipments valued at less than $2,000 do not need to be reported, so it is possible that the fraction of actual trade flows is larger. Available estimates of low-value shipments suggest that the difference in the total fraction is unlikely to be great.

TABLE 1

Missing Product-Country Trade Flows for Different Classifications

Classification level	Number of traded products	Missing trade flows
10 digit	8,877	82%
6 digit	5,182	79%
4 digit	1,244	66%
2 digit	97	36%

Sources: Census Bureau and author's calculations.

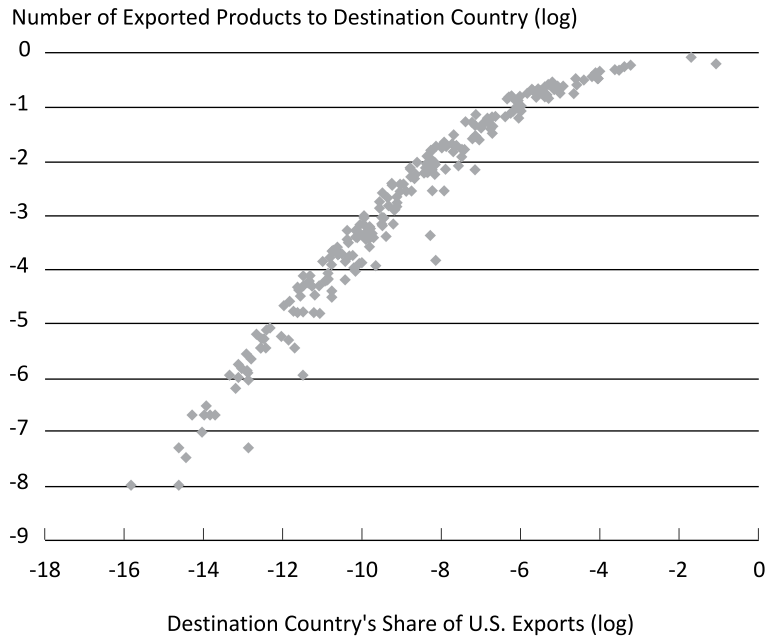
Regarding which products are sold where, there is a clear pattern based on market size. For each destination country, it is possible to construct a measure of its market size, starting with the country's gross domestic product and adjusting it by the country's distance to the U.S. and by other variables known to increase trade costs. The resulting formula — known as the "gravity equation" in trade for its similarity to physics: closer and larger objects (or countries) exert a greater pull on (or trade more with) others — is excellent at predicting bilateral trade volumes.

The data show clearly that the U.S. sells more products to and buys more products from larger, closer countries. Most possible trade flows with Canada and Mexico do indeed occur. Similarly, the U.S. engages in much trade with Germany and Japan, which are farther away but represent economic heavyweights.[5] Figure 1 plots each destination country's market size against the number of products the U.S. sells there. Because the differences in market sizes across countries are very large, we need to use a log scale for the axes.[6] Market size is captured as the country's market share in total U.S. exports. The number of U.S. products sold clearly increases, becoming quite tight as market size increases. Note that the number of exported products increases rapidly at first but then slows down for destinations with very large market sizes. In these countries, most of the products are traded. Recall that by virtue of the classification system, no more than about 9,000 products can be sold to a given country.

Of course, different products also have different market sizes. It is perhaps not surprising to learn that automobiles make up a larger fraction of U.S. trade than turnips do. There are several techniques to identify variation in product-market size. A simple approximation is to use aggregate trade shares across products or, for example, the trade shares for Canadian exports. Using either measure, the data are clear: The U.S. is more likely to export products with large markets to more countries. Figure 2 brings this point home. It is a scatter plot as in Figure 1,

FIGURE 1

More Products Exported to Countries with Larger Markets



Sources: Census Bureau and author's calculations.

[5] Japan's GDP is about triple Canada's, and Germany's is about two times bigger.

[6] A log scale measures relative rather than absolute differences. For example, if a country is twice as big as another country but half the size of a third one, it will appear to be halfway between the two in a log scale but would instead show up much closer to the smaller country in a linear scale.

on log axes. Now we plot the market size of the product against the number of countries to which the product is sold. Again, the relationship increases, though the trend is noisier than it is for countries.

FIRMS AND EXPORTS

Countries do not decide what to trade; firms and consumers do. So let us look at firms.[7] Only 18 percent of U.S. manufacturing firms sold goods abroad in 2002, and the ones that did were consistently larger: Their total foreign and domestic sales were four to five times larger on average than those of firms that did not export. There are also systematic differences regarding employment, wages, and measures of firm performance such as labor productivity. Exporting firms employ more workers, pay higher wages, and have higher average output per worker-hour than nonexporting firms. In contrast, the differences across sectors were small. Less than 40 percent of the firms had foreign sales in the sectors for computers and electronic products and electrical equipment, appliances and components — the quintessential modern traded goods. The share of firms that exported was much lower in other sectors — as low as 5 percent in printing, publishing, and similar products, and 7 percent for furniture and fixtures.

So perhaps we are zeroing in on the reason the U.S. trades so few products to so few countries, yet where it does trade it does so in large quantities: Most U.S. firms are either unable or unwilling to sell any amount abroad, but those that do are very large and competitive.

WHY IS THERE NOT MORE TRADE?

One possibility accounting for missing trade flows is that the U.S. is specializing in some products due to a comparative advantage, perhaps because of different factor endowments such as access to raw materials or a skilled workforce. This hypothesis runs afoul of the data: Most trade is intraindustry. For example, the U.S. sells cars to Germany, but Germany also sells cars to the U.S. Thus, neither can be said to specialize in cars. The relationship with size, especially at the firm level, is also puzzling. For the comparative advantage theory to hold, the source of the advantage would need to be systematically related to market size.

Trade economists instead currently favor a theory based on economies of scale in trade. The basic idea is that a firm faces a fixed cost, independent of actual sales, when accessing a foreign market. Unless the net revenues can cover the fixed expense, the firm would not sell in that particular market. Clearly, net revenues are tied to market size; thus, economies of scale can explain the relationship between missing trade and market size and why some trade flows go missing.[8] Most of these models trace their lineage to Melitz (2003).

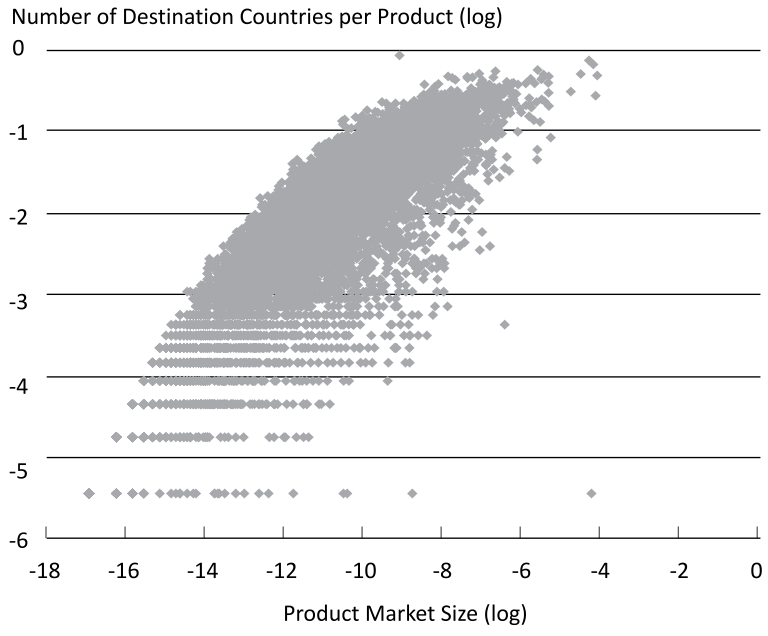
Economies of scale can also explain why some firms export and some don't. More productive firms are able to sell more and thus are more likely to be willing to incur the fixed cost. They will employ more workers and venture

[7] Unfortunately, firm-level data are proprietary, but we can look at the big picture by combining the work of several economists as well as Commerce Department trade data from 2002. For a complete overview of exporters, see Alessandria and Choi (2010). A classic article in the literature is Bernard, Jensen, Redding, and Schott (2007). The facts that follow pertaining to firms and foreign sales are based on their analysis.

[8] Baldwin and Harrigan (2011) document how several models with economies of scale perform against the data, focusing on the facts reported in the previous section.

FIGURE 2

Products with Large Markets Exported to More Countries



Sources: Census Bureau and author's calculations.

into additional product lines. The same can be said about firms capable of producing better-quality or high-margin goods. See *The Relationship Between Size and Exporting* for a useful example.

Economies of scale in trade have some important implications in the event of a reduction in trade costs or tariffs. In particular, they predict that trade leads to an improvement in productivity industrywide, a very appealing prospect to trade economists, who have long suspected that liberalizing trade boosts efficiency. The mechanism is quite simple. As discussed before, more productive firms are more likely to be exporters. Now, a reduction in trade costs has two immediate effects. First, it increases the revenues of exporters as the cost of shipping their products to foreign markets decreases. Second, it reduces the revenues of domestic firms that do not export as they face increased competition from foreign firms that do export.

In short, exporters expand, while nonexporters contract. Employment then shifts from the latter to the former. Since exporters are more productive, the average productivity of the industry and the economy increases. Although the increase in overall productivity represents a long-run gain for the economy, short-run costs may be significant. Smaller, less productive firms that sell only domestically may be driven out of business, leaving their workers unemployed, at least for a time. If these firms are concentrated geographically or economically, the reallocation of resource and workers to the more productive, exporting firms may be slow.

The Relationship Between Size and Exporting

Say U.S. firms must incur a cost of $10 to gain access to a foreign market. Trinkets & U is a successful firm known for its uniquely useful trinkets. For each dollar's worth of trinkets sold, the firm makes a profit of 10 cents. Canada, a large country accessible by road and rail, is an attractive market. The firm knows it would sell $200 worth of trinkets, making $20 in profits. It will thus recoup the $10 cost of exporting, and it gladly incurs it.

Now consider Andorra, a small, landlocked country across the Atlantic Ocean. The U.S. firm expects to sell no more than $40 worth of trinkets there, which adds up to a paltry profit of $4 — not enough to cover the expense of $10 needed to access the Andorran market.

Returning to the U.S., we meet Gadgets Inc., a failing firm that produces quite useless gadgets. As a result, Gadgets will sell only $120 worth of goods in Canada. To top it off, an inefficient production process shaves most of the profit down to only 5 cents per dollar. As a result, Gadgets Inc. does not sell in Canada, since it would net only $6 in revenues, not enough to cover the fixed cost of $10.

Note that if Gadgets Inc. would have managed to sell as much as Trinkets & U, even while making only 5 cents per dollar, it would have chosen to export to Canada. Similarly, if it had sold only $120 but had a margin of 10 cents per dollar, it would have gone ahead and exported. The larger picture should be clear: Firms with low productivity and/or small margins are less likely to be exporters. These firms are also likely to be smaller, selling less and employing fewer workers.

IS TRADE BROADER THAN IT SEEMS?

Economies of scale theories perform reasonably well in explaining why trade is more likely to involve large firms, high-demand products, and large, close destination countries. But as we will see, these theories run afoul of the data in some key respects. First, we see lots of small — actually, tiny — trade flows, adding up to no more than a couple of shipments in a given year. Barriers to trade thus cannot be particularly large, or otherwise these firms are losing money. Second, a lot of products and destinations appear and disappear year to year in the data, only to reappear years later, which we would not expect if economies of scale were the whole story. This infrequency seems to suggest that trade barriers are not only small but change often. These observations lead us to explore an alternative hypothesis: The U.S. does trade most products with most countries, just not very frequently. That is, a missing trade flow does not indicate that the U.S. never sells a particular product to a particular country; it just has not done so in the year being examined. What is so special, after all, about the time it takes the Earth to go around the sun? It may well be that no trade shipment enters the U.S. in the time it takes to read this article. We will be overreacting a lot if we conclude that we have stopped trading completely!

The distinction between infrequent and nonexistent trade flows is very important, for the latter are the backbone of the trade theories based on economies of scale. Infrequent sales cannot possibly bring home much net income. Their existence is thus compatible only with a very low fixed cost of accessing the foreign market. In other words, the barriers to trade, through the lens of a model with economies of scale that emphasizes fixed costs, would have to actually be small if there is infrequent trade.

Now, it is clearly untrue that all trade flows are infrequent; we could end up with no trade at all! In Armenter and Koren (forthcoming), we show how to develop a simple statistical model that uses the data on aggregate country and product trade flows to compute a probability that a shipment belongs to a particular product-country pair. The number of shipments exactly reflects the data, but each of them is randomly assigned to a product and a country category, akin to balls falling into bins at random. As simple as it sounds, the model is capable of predicting missing trade flows (that is, empty bins) and the size of the observed trade flows (how many balls do we expect to find in a nonempty bin?). A trade flow's relationship with the size of a firm or market is given by the probability that a trade flow in each category will occur, or, if you will, the size of the bin. For instance, Canada and autos have large bins and thus are very likely to catch many balls. Turnips and Andorra have very small bins, and thus it is very likely that they end up catching no balls at all. The framework does not elaborate on why Canada has more total trade than Andorra or autos sell better abroad than turnips; we just take these as given or approximate them through a gravity equation (for countries) and some model of product-specific trade costs (for products).

An example may be useful at this point. Assume that Canada's market size is 100 times larger than Andorra's. For the sake of simplicity, these two countries are the only trade partners the U.S. has, and we do not distinguish among products. The Canadian bin is 100 times larger than the Andorran bin. Total trade is 10 shipments per year. The difference in bin sizes implies there is a 99 percent chance a shipment goes to Canada, and only a 1 percent chance it goes to Andorra. The probability that more shipments end up going to Andorra in any year is virtually negligible: Canada is expected to receive 9.9 shipments, while Andorra only a tenth of a shipment.

But shipments (or balls, for that matter) do not split! What does it mean for Andorra to be expected to have a tenth of a shipment? It simply says that a shipment to Andorra is expected to be observed about once every 10 years. In other words, the probability that we observe any shipment to Andorra in a given year is only 10 percent.

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Given data limitations, it is not straightforward to sort out if a missing trade flow is actually nonexistent or just infrequent. There are, though, some observations that are distinct between the two hypotheses. If the number of shipments per product-country pair is zero, we cannot say much; that trade flow may be infrequent and we were just unlucky, or it may never happen. Now, things are different if the trade flow is observed. The infrequent trade hypothesis predicts we should see a very small number of shipments, possibly a single one. For, if a shipment is a rare event, two shipments are twice as rare! In contrast, the economies of scale hypothesis suggests that we should see a substantial number of shipments — enough for the firm to cover its fixed costs of accessing the market.

The data are clear on this aspect. Table 2 breaks down all the product-country pairs with positive trade for U.S. exports in 2005 according to the number of shipments that year. Among all pairs shipped that year, the most common number of shipments was one. The second most common was two, and so on. Indeed, the number of shipments per trade flow conforms very well with what are called *count data*. This is usually associated with rare or infrequent events.[9]

What happens when we look beyond a single year's data? After all, if a trade flow is not observed in one year, why not look at two-year or five-year intervals? Indeed, as more years are combined, the number of missing trade flows decreases, albeit slowly. Table 3 shows the share of missing product-country trade flows when several years are combined.[10] However, it would be quite unfair to dismiss the models

[9] A classic example was the tally of deaths by horse kicks in the Prussian army, collected by Ladislaus von Bortkiewicz at the end of the 19th century. See Quine and Seneta (1987) for a discussion of the famous data and the associated law of small numbers.

TABLE 2

Shipments Across Traded Pairs

Number of shipments	Share of traded pairs
1	28.7%
2	12.8%
3	7.8%
4	5.4%
5	4.1%
6-9	9.9%
10 and above	31.4%

Sources: Census Bureau and author's calculations.

of economies of scale at this point; it could well be that, over the time examined, trade barriers decreased, thus explaining the increasing number of observed trade flows.

Another interesting observation surfaces when we extend our view beyond one year. When we consider two consecutive years, we can look for product-country pairs that appear anew in the second year as well as pairs that were dropped — that is, pairs that were observed in the first year but not the second. The data also speak loudly here: There was a lot of churning. That is, a lot of new trade flows cropped up, and a lot were dropped. Table 4 reports the new product-country pairs traded from year to year, as well as the pairs that stopped being traded, as a rate over traded pairs in the previous year. The second column repeats the calculation by weighting the pairs by their trade value. Every year close to one-quarter of the product-country pairs observed had not been traded the year before. And more than 20 percent of them were not traded the next year! In net terms, the total count of product-country pairs grew just over 2 percent, a full order of magnitude less than the gross changes.

[10] Data are an average of the annual changes from 1990 to 2001 for U.S. imports. Import data over that period are somewhat more consistent regarding product classifications.

Now, this churning is a challenge to models with economies of scale but is to be expected in a model of infrequent trade. To be consistent with economies of scale models, the churning would imply a lot of year-to-year variation in trade barriers, but this seems unlikely. In the infrequent trade hypothesis, though, churning comes naturally. For example, all trade flows that are expected to be observed once every two years are bound to create churning.

Viewing "missing" trade flows as simply infrequent suggests we should not be looking at frictions or costs at the firm or product level. That is, the question should not be why firms do not trade or products are not traded with certain countries: We should instead ask why there are not more shipments. There are certainly some fixed costs per shipment — for example, whether a truck is full or half empty, a firm needs to pay the full wages of the driver. These fixed costs cannot be too large, since more than half of the shipments are valued at $15,000 or less. And then some goods such as planes and satellites are so large that they are necessarily a single shipment. These goods tend to be durable, and we should not expect countries to purchase them frequently. For example, Andorra may buy a U.S. plane and not buy another until it is time to replace it several years later.

CONCLUSION

Trade is now a pervasive fixture of the modern world. Yet, economists are still explaining why there is not even more trade and, in particular, why so few products are shipped to and from most countries in a given year. Models with economies of scale are the leading theory of missing trade flows because of their ability to explain trade's relationship with market size and the characteristics of firms that export. There are questions, though, whether the data on actual trade flows support some unique implications of these models. Of course, it takes a model to beat a model, and until recently there had been no viable alternative to theories featuring economies of scale. Recent work suggests that many missing trade flows are perhaps simply low-probability but not zero-probability events.

TABLE 3

Missing Pairs over Multiple Years

Number of years	Share of missing trade flows
1	92.0%
2	90.3%
3	89.1%
5	86.6%

Sources: Census Bureau and author's calculations.

TABLE 4

Entry and Exit, by Count and Value

	By count	By value
Newly traded pairs	24.6 %	1.1%
Disappearing pairs	22.4%	0.8%
Net difference	2.2%	0.3%

Sources: Census Bureau and author's calculations.

How Much Larger Should We Expect Exporters to Be?

Can the idea of infrequent trade also explain why some firms export and some do not? The answer is no. It takes only one product sold to one foreign market for a firm to qualify as an exporter. Thus, to assert that nonexporting firms are just infrequent exporters, we would need to say that trade, as a whole, is infrequent, which it is not. In Armenter and Koren (forthcoming), we show that the balls-and-bins model predicts that about three-quarters of the firms should be exporting — completely at odds with the data. Indeed, the model also gets wrong the relationship with size. Even though the model predicts close to four times more exporters than in the data, exporters are predicted to be even larger than the data show.

In Armenter and Koren (2010), we show that models with economies of scale also overpredict the size of exporters — by a lot. The reason is simple. It may appear that a four- or five-fold difference in size is large. But in the context of the distribution of firm size, it turns out to be very small. If larger firms are more likely to be exporters, they should be concentrated at the top of the firm-size distribution. Since about one-fifth of the firms export, the average firm in the top fifth of the firm size distribution should be a good approximation for exporters. Yet, the average top-quintile firm is more than 100 times larger than the average firm in the bottom four quintiles! That is, the theory overstates the size advantage of exporters by a factor of 25.

This suggests that productivity is not the only determinant of whether a firm exports. As a matter of fact, it is very likely not even the main determinant. Other determinants include the firm's location within the U.S., its ethnic or family links to the destination country, and the industry the firm belongs to.

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