Calculating Time in South–South Trade

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Executive Summary

Time in trade is an important factor in today's global economy. There is a growing demand for timely delivery of goods, rooted in (1) the shift in world trade from bulk commodities to inherently time-sensitive complex manufactures, (2) wealthy consumers' preference for precise product characteristics and ability and willingness to pay for fast delivery, and (3) increasingly segmented production chains. In 2007, USAID funded Dr. David Hummels (Purdue University) to research how time affects trade, what costs time imposes on trade, and how those costs can be measured in dollars.

In 2010, Dr. Hummels gained access to a database of South American trade and shipping data from the Latin American Association for Integration (ALADI). The South American import data from the ALADI dataset are very similar to U.S. import data used in 2007. This presented an interesting opportunity to determine if the 2007 methodology could be applied to South American imports data to explore how time specifically affects South-South trade. While the ALADI dataset focuses exclusively on South American imports data, it is not a stretch to extrapolate that the characteristics of trade revealed through analysis of the ALADI data could apply to other regions in the developing world.

South-South trade is increasingly relevant to USAID- and other donor-funded trade capacity building programs. The OECD has reported an increase in South-South trade over the past two decades (albeit from a relatively small base) and has also pointed out that the potential benefit from freer South-South trade may be at least as large as the gains developing countries can obtain from better access to markets in "developed" countries (OECD, 2006). This supports the push for greater regional integration in regions such as sub-Saharan Africa. As reported by the World Bank, during 2000-2008, Africa's exports grew by 18 percent per year, driven by exports to low and middle-income countries (World Bank Group, 2011). The OECD also reports that "there is considerable scope for increasing South-South trade by reducing distance-related trade costs to levels prevailing from other trade flows".

METHODOLOGY

The Hummels/USAID 2007 research proceeded in three steps: (1) estimate the value of one day saved in transit for each product, using data on U.S. imports from 1991–2005; (2) calculate the per-day value of time savings for each country, on the basis of the goods it trades; (3) calculate tariff equivalents for import and export waiting times by combining each country's per-day value of time savings with its Trading Across Borders data from *Doing Business*. Once the ALADI

dataset was "cleaned", preliminary analysis raised some intriguing differences between the US imports sample used in 2007 and the South American imports.

Directly applying the methodology from Hummels/USAID (2007) to South-South trade required that for each product that will be included in the data sample:

- There is a positive quantity of bilateral trade ("trade flows") between an exporter and importer; and
- Exporters employ a mix of air and ocean shipments and the data must include shipment costs by transport mode and delivery time by mode. This provides the information necessary to evaluate the tradeoff between the added benefit versus the added cost of faster air shipments.

While these were common occurrences in US imports data, they were much less common in the South American imports data.

This led to the following observations: (1) South-South trade is rare (2) shipping times are slow; and (3) air cargo is less common and mode mixing is less common. Given the rarity of trade flows and of "mode mixing" in the South American dataset, the methodology for quantifying time-in-trade had to be adapted to address a key question: could time delays cause some South–South exporters to trade certain commodities in diminished quantities? More importantly, could the time delays cause potential traders not to even try trading that good at all?

Using a probability model as our methodological basis, we began to examine the role of time delays on trade and adapt the 2007 methodology to estimate the value of South-South time-in-trade. This analysis proceeded in three steps:

1) Estimate the probability that a product is traded, and account for the possibility that the most time sensitive goods are "selected" out of the sample
2) Estimate per day time costs for each product, conditional on trade being observed.
3) Calculate the aggregate impact of per day time costs using information on the time cost per product and the importance of each product in trade.

As expected, the time it takes to trade with southern countries is much longer than with the North. South-South time-in-trade values are roughly one half of Northern time values; in other words, developing countries appear to value expedited trade significantly less than their Northern counterparts. Another implication of this is that the most time-sensitive products that an exporter trades with the rest of the world never make the profitability cutoff for South American trade. The most time-sensitive goods simply disappear from the trade bundle. This effect is especially pronounced for southern exporters.

DISCUSSION

Based on the results of our research using the ALADI dataset, we can begin to revisit the questions posed in the introduction to this paper. Our research highlights three key aspects of South-South trade vs. the overall trade flows addressed in the Hummels/USAID study from 2007:

1) *US importers value time in trade more than South American importers*. Conditional on trade taking place, South American buyers value a day saved at 0.42 percent ad-valorem, or roughly half the value for US buyers estimated in Hummels/Nathan (2007). Why do US importers value time in trade more than South American importers?

   - *Composition of South-South trade.* There are very large differences across products in their time sensitivity. Because of these differences, the aggregate impact of time delays on the economy depends on what goods a nation trades. The broad commodity composition of South–South trade is quite different than North–North or North–South trade, implying different aggregate sensitivity.
   - *Timeliness as a luxury.* Buyers value timeliness in the same way that they value higher-quality goods. It then follows that demands for timeliness, like demands for higher-quality products, may be responsive to income differences. The higher income of U.S. consumers may then be reflected in greater time sensitivity for trade. South-South trade, involving lower-income consumers, may exhibit lower degrees of time sensitivity as buyers opt for slow-arriving and therefore less-expensive products.
   - *Price and quality of the goods being traded.* For many goods there is a systematic relationship between product prices and the income level of the exporter and the importer. High-income exporters specialize in higher-quality market segments and therefore sell higher-priced goods, while low-income exporters specialize in lower-quality, lower-priced market segments. The same pattern appears on the buying end, as higher income translates into the purchase of higher-priced goods. A consequence is that the composition of South–South trade, defined in terms of product price and quality, may be significantly different, even in a single category of goods such as footwear.
   - *Organization of production.* If firms fragment production so that value is added around the globe before final assembly in a location, timely delivery becomes much more important. A component that arrives late can shut down an entire assembly line. This suggests that time sensitivity depends not just on buyers' preferences for fast-arriving goods, but on the organization of production. It is well known that U.S. production is increasingly fragmented, and this may explain the high degree of time sensitivity found in the earlier work. If South–South trade is not characterized by fragmented production to the same degree, the same products may be much less time sensitive.

2) *The aggregate impact of delays on South-South trade is actually larger than US trade*. Transit times for South-South trade are much longer than for US imports. The average shipping time to our South American importers from low income exporters is five weeks, and nearly seven weeks once we include inland times. In contrast, average shipping times to the US by boat are less than four weeks, and perhaps only a few days from Canada and Mexico (representing 27 percent of US imports in 2010). In short, while US buyers value place double the value per day on time, the time delays they face are roughly half as long. The cost of avoiding delays (by choosing air shipment) is also higher for South-South trade.

3) *Time delays not only reduce the quantity of South-South trade, they reduce the likelihood that trade flows take place at all.* Our research shows that an important effect of time delays is not only to cause South–South country pairs to trade a product in diminished quantities, but also

not to trade a product at all. This may help explain why South–South trade is characterized not just by lower quantities of trade, but by a smaller and less diversified set of traded goods.

CONCLUSION/NEXT STEPS

As in 2007, this 2010-2011 research can generate important discussion research on the role of time-in-trade. While there are many factors involved, a reasonable assumption from this research is that to increase South-South trade, one needs a larger reduction in time delays than trade with richer countries. This may appear daunting, however, given the large time delays currently, there is a lot of room to move up here and improve. USAID-funded trade capacity building projects—with their focuses on supporting greater regional integration, streamlining and harmonizing customs and logistics procedures, and improving the efficiency of transport corridors (as expressed by reductions in time and cost) are helping host country public and private sector actors to facilitate trade and close the time gap.

The current research also reinforces the positive relationship between export diversification and economic growth, and poses intriguing questions worthy of further study. The highly undiversified trade bundles that emerge from the current research are a puzzle. The extraordinarily long time to trade may be an important piece in understanding this phenomenon. While our calculation provides the average change in the probability in trade, it could also be refined to assess how close any particular country pair is to the profitability threshold and whether a reduction in time to trade would tip them over that threshold.

Having this information could be a valuable metric from which to design future donor-funded programming in export promotion/competitiveness, or to adjust ongoing programs. Such a calculation could help USAID and developing country partners make informed decisions about the level of support required to increase the competitiveness of given products exported to specific markets—both Northern and Southern. The research presented in this paper represents only the beginning of what is possible; TCBoost looks forward to discussing with USAID the possibility of continuing this research on this or a future USAID-funded project.

1. Introduction

Time in trade is an important factor in today's global economy. There is a growing demand for timely delivery of goods, rooted in (1) the shift in world trade from bulk commodities to inherently time-sensitive complex manufactures, (2) wealthy consumers' preference for precise product characteristics and ability and willingness to pay for fast delivery, and (3) increasingly segmented production chains. In 2007, the USAID-funded TCBridge project funded Dr. David Hummels (Purdue University) to research how time affects trade, what costs time imposes on trade, and how those costs can be measured in dollars.

Assuming that buyers value goods that arrive quickly and are willing to pay more for those goods, Dr. Hummels used U.S. imports data to estimate the value of time savings by calculating the premium for air shipping that firms are willing to pay to avoid an additional day of ocean transport. The resulting paper, "Calculating Tariff Equivalents of Time in Trade" (2007) has been widely cited in the trade capacity building community. Putting a dollar figure to time delays in trade has demonstrated in practical and relatable terms the importance of improving customs administration, border management, transport corridor efficiency, and logistics operations in developing countries.

In 2010, Dr. Hummels gained access to a database of South American trade and shipping data from the Latin American Association for Integration (ALADI). The South American import data from the ALADI dataset are very similar to U.S. import data used in 2007; they report information on shipment value, weight, and freight charges by transportation mode. This presented an interesting opportunity to determine if the 2007 methodology could be applied to South American imports data to explore how time specifically affects trade between developing countries (i.e., South-South trade).

South-South trade is an increasingly relevant topic for USAID- and other donor-funded trade capacity building programs. The OECD has reported an increase in South-South trade over the past two decades (albeit from a relatively small base) and has also pointed out that the potential benefit from freer South-South trade may be at least as large as the gains developing countries can obtain from better access to markets in "developed" countries (OECD, 2006). This supports the push for greater regional integration in regions such as sub-Saharan Africa. As reported in the World Bank's trade capacity building strategy, during 2000-2008, Africa's exports grew by 18 percent per year, driven by exports to low and middle-income countries (World Bank Group, 2011). The OECD also reports that "there is considerable scope for increasing South-South trade by reducing distance-related trade costs to levels prevailing from other trade flows".

The challenge to examining South-South time-in-trade has traditionally been the lack of available and reliable trade data; it is rare for “Southern” countries or regional blocs to collect trade statistics with data on shipping modes and costs. This underlines the importance of gaining access to the ALADI dataset. While the dataset focuses exclusively on South American imports data, it is not a stretch to extrapolate that the characteristics of trade revealed through analysis of the ALADI data can readily apply to other regions in the developing world.

This paper begins with a discussion of research methodology. This includes revisiting the assumptions and methodology employed in the 2007 research and explaining how the approach was modified to accommodate the available South American imports data from the ALADI dataset. The complete, detailed methodology is presented in an appendix. Chapter 3 presents some of the differences between US and South-South trade; including the fact that the costs of international trade for developing country exporters may not only reduce the volume of trade but may also discourage exporters from trading certain goods at all. This has implications for export diversification and trade-led growth in developing countries: a key point of the final chapter (Chapter 4).

2. Methodology

This chapter revisits the methodology used in 2007 to calculate time-in-trade, addresses observed characteristics of South-South trade and explains how the time-in-trade methodology was adapted to suit the parameters of the available South American imports data.

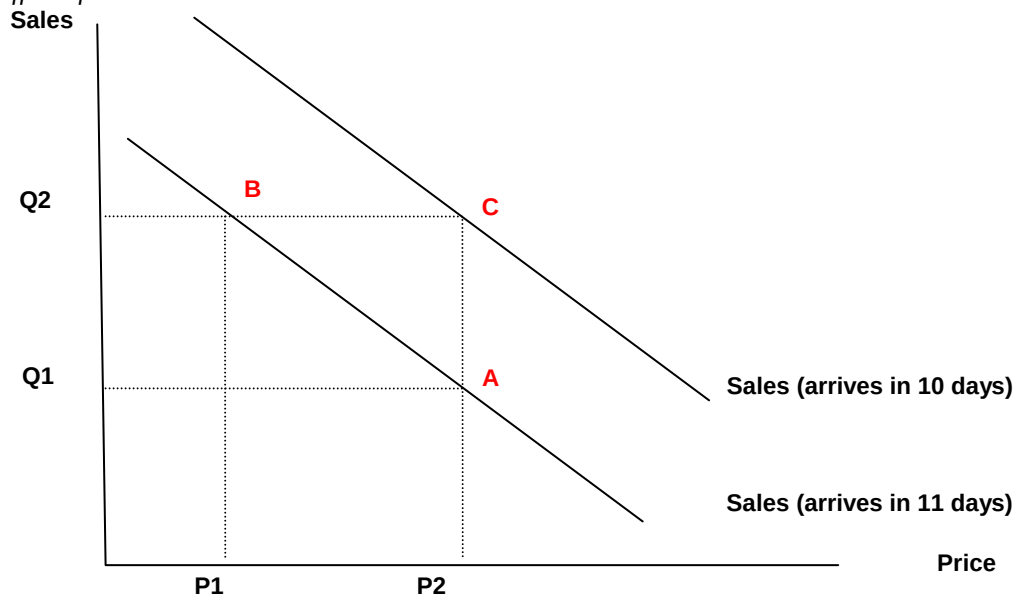
REVIEW OF 2007 TIME-IN-TRADE METHODOLOGY

The research methodology for Hummels (2001) and Hummels/USAID (2007) assumed that buyers value goods that arrive quickly and are willing to pay more for those goods. The 2007 research used U.S. imports data to estimate the value of time savings by calculating the premium for air shipping that firms are willing to pay to avoid an additional day of ocean transport. The choice of air versus ocean shipping depends on benefits and costs of rapid delivery. The *benefit* is the value the buyer attaches to saving a day in transit, while the *costs* are the higher freight prices for air shipping. Using the estimated costs and benefits it is possible to calculate buyers' willingness to pay to save a day in transit.

Put simply, importers are willing to buy a larger quantity of a good if it is sold for the same price but arrives more quickly. This approach can be summarized in Figure 1 which relates product sales to price and to arrival times.

Figure 1

Effect of Price and Timeliness on Sales



A good offered at price P2 that arrives in 10 days can sell Q2 units (point C). That same good offered at price P2 that arrives in 11 days sells only Q1 units (point A). When looking at trade data with many possible exporters, we can directly estimate the effect of longer ocean shipping times on quantities by calculating the reduction in demand (from Q2 to Q1) that results from an increase in shipping times. Some trade partners are near to the importer so that goods reach the market via ocean cargo in a short period of time and sales losses from ocean shipping are small. Other trade partners are farther away, transit times for ocean shipping are longer, and the sales losses are larger.

We also want to know the tariff equivalent of this time cost so that we can compare the barrier associated with time lags to other barriers such as tariffs. This also allows us to calculate the total effect of time costs, aggregating over all goods. To calculate this we need to know how large the loss in sales is compared to a change in prices induced by a tariff.

Take, for example, demand for goods arriving in 11 days. We start at price P1 with sales Q2 (point B). Imposing a tariff causes the price to increase to P2 and sales to fall to Q1. This represents a move along the demand curve to point A. The percentage change in quantity given the percentage change in price is the price elasticity of demand, denoted as σ.[1] This loss in sales is exactly the same quantity change that resulted from holding prices fixed at P2 but increasing shipping times by one day (from point C to point A).

Put another way, greater time lags are equivalent to imposing a higher tariff in terms of the loss in sales. We can represent the quantity shift from C to A as $\sigma\tau$, where τ is the tariff equivalent of the time cost multiplied by the price elasticity of demand σ. We are not interested only in the loss in sales, however; we want to know τ itself, and this requires knowing the price elasticity of demand.

To estimate the values of these parameters, the methodology developed in Hummels (2001) and employed in Hummels/USAID (2007) used data on the reduction in shipment times resulting from air-shipping goods, and the premium paid to use air freight. Air cargo is systematically more expensive than ocean cargo, but this premium varies across exporters and goods. Variation across exporters and goods in the air freight premium can then be used to identify the price elasticity of demand σ. Air shipments arrive more quickly than ocean shipments, but the time penalty to ocean-ship a good varies across exporters. Variation across exporters in the number of days it takes to ocean-ship a good can then be used to identify how sensitive quantities sold are to changes in time delays, $\sigma\tau$. Dividing the estimate of $\sigma\tau$ by the estimate of σ, we arrive at the tariff equivalent of the time cost, τ. This methodology effectively combines information on the sales gained through fast air cargo with information on the sales lost by paying the air freight premium to calculate the tariff equivalent penalty of time delays.

Above we described the move from P1 to P2 as a tariff increase facing a particular exporter. We can equivalently view this as a comparison between two different exporters one of which produces at a low price and another which produces at a higher price. Viewed in this way, exporting success is a function of both comparative advantage and time delays. A high cost

[1] In the detailed methodology section we describe these sales curves in log form so that the slope of the curve is exactly the elasticity of demand, sigma.

exporter can overcome their cost disadvantage by getting goods to market more quickly, and conversely, a low cost exporter can lose their cost advantage if they face large time delays.

Based on these assumptions, the Hummels/USAID 2007 research proceeded in three steps: (1) estimate the value of one day saved in transit for each product, using data on U.S. imports from 1991–2005; (2) calculate the per-day value of time savings for each country, on the basis of the goods it trades; (3) calculate *tariff equivalents for import and export waiting times* by combining each country's per-day value of time savings with its Trading Across Borders data from *Doing Business*. The study found per-day tariff equivalents ranging from 0.8 percent ad valorem (for high-income OECD imports) to 1.5 percent ad valorem (for South Asian imports). The tariff equivalents of total wait times were estimated to be significantly higher than tariffs themselves, ranging from 4.6 percent for the high-income OECD to 29.1 percent in South Asia.

OBSERVED CHARACTERISTICS OF SOUTH–SOUTH TRADE

The South American import data from the ALADI dataset reports information on shipment value, weight, and freight charges by transportation mode. Once the ALADI dataset was "cleaned", trade flows were observed for all exporters worldwide into six South American importing countries (Argentina, Brazil, Chile, Colombia, Ecuador, and Peru) for every HS6 product in years 1995 and 2000-2005, inclusive. Preliminary analysis of this data raised some intriguing differences between the US imports sample used in 2007 and the South American imports.

Directly applying the methodology developed in Hummels (2001) and adapted in Hummels/USAID (2007) to South-South trade requires that for each product that will be included in the data sample:

(1) There is a positive quantity of bilateral trade ("trade flows") between an exporter and importer; and

(2) Exporters employ a mix of air and ocean shipments and the data must include shipment costs by transport mode and delivery time by mode. This provides the information necessary to evaluate the tradeoff between the added benefit versus the added cost of faster air shipments.

While these were common occurrences in US imports data, they were much less common in the South American imports data. Below we discuss these, and some other observed characteristics of South-South trade, per our examination of the ALADI dataset and other sources.

South-South Trade is Rare

In the South American data, a positive trade flow was a relatively rare occurrence. Table 1 shows the extent of trade between the South American importers and regional exporting groups in 2004. The first column reports the number of exporting countries in each region; the second column presents the percentage of country pairs with no trade in any product. For example, there are 23 countries in the "High Income: OECD" exporter group and 6 South American importers for 138 country pairs. Of these, only 1 (or 0.7 percent of the total) has no trade. However, there is no trade in 36 percent of South America–East Asia & Pacific pairs and no trade in 55.3 percent of South America-Sub Saharan Africa pairs.

The sparseness of trade becomes even more pronounced when we look at product level trade. Measured at the HS6 product level, there are 4,998 products reported in the South American imports data. The third column of Table 1 focuses only on those country pairs that trade at least one product, and reports the number of distinct HS6 products that Argentina imports from each exporter in each region. On average, Argentina purchases 408.7 products from an OECD exporter, 64.5 from a South Asian exporter, and only 3.5 from a Sub-Saharan African exporter. A similar pattern is seen for other South American importers in the remaining columns.

Of course, the sparse nature of South-South trade may result from Southern exporters having a comparative advantage in a fairly narrow range of products. Consider then only those products that a country succeeds in exporting to at least one destination worldwide. There were 6.8 million of these exporter x product combinations in our data, but only 7.1 percent of them had positive trade flows with the six South American importers. The problem is not exporting, per se; the problem is exporting to South America.

Table 1

Extent of Trade between South American Importers and Regional Exporting Groups

Exporting Region	No. of Exporters in Region	Zero Trade % of Country Pairs	Average No. of HS6 Products Traded					
			Argentina	Brazil	Chile	Colombia	Ecuador	Peru
World	157	27.5	122.2	165.3	101.8	102.8	157	115.3
High Income: OECD	23	0.7	408.7	660.4	321.4	366.0	286.1	335.1
South Asia	6	11.1	64.5	59.3	28.4	47.0	9.7	33.8
Latin America & Caribbean	31	19.9	78.1	59.3	76.1	122.4	143.1	144.6
Europe & Central Asia	24	20.1	4.6	19.1	5.3	7.7	10.0	2.4
Middle East & North Africa	16	21.9	6.9	11.8	4.9	2.8	3.9	2.8
East Asia & Pacific	19	36.0	163.2	177.5	92.7	101.3	48.0	99.6
Sub-Saharan Africa	38	55.3	3.5	3.4	4.5	0.4	0.5	2.0

Shipping Times Are Slow

South–South trade is characterized by low volumes, and poor service connectivity between countries. It is quite common for firms engaged in trade to enjoy no direct connection between South–South country pairs and to route their goods indirectly through major hub ports. Rather than steaming directly across the Southern Atlantic Ocean, West African goods may travel north to Rotterdam in Europe, west to Hampton Rhodes on the U.S. Eastern seaboard, and finally south to Brazilian and then Argentine ports.

How important is the lack of direct connection for South America? Using a comprehensive shipping schedule that reports all ocean vessel movements between all ports worldwide (Port2Port Evaluation tool at www.compairdata.com), we calculated the number of exporting countries with direct connections to each South American importer. Eliminating landlocked exporters we focused on the largest 120 exporters world-wide. South American importers had direct shipping connections to only 22 percent of these exporters, and a majority of these direct connections were with Western Hemisphere countries.

A consequence is that shipping times to South America are exceedingly slow, and this effect is more pronounced for Southern exporters. Table 2 reports average ocean transit times and inland time to trade for US imports and South American imports with both high- and low-income exporters. South American imports from low-income exporters take almost three weeks longer to arrive than US imports from high income exporters.

Table 2

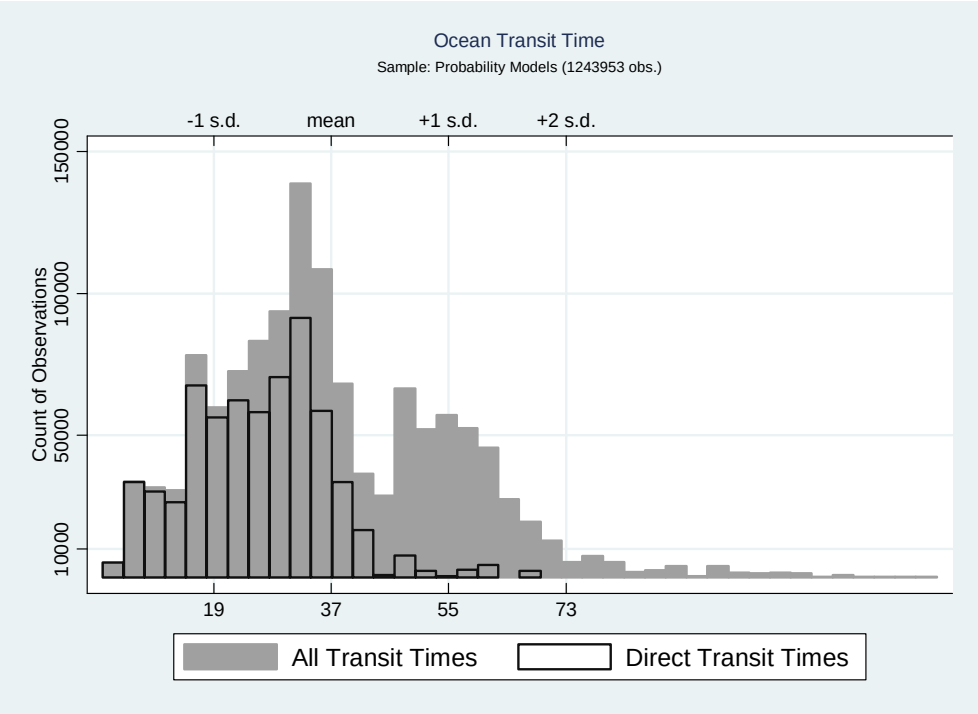
Time to Trade for United States and South America

	Ocean Transit Time	Inland Time	Total Time in Trade
U.S. IMPORTS			
High-income exporters	22	5.6	27.6
Low-income exporters	29.5	12.1	41.6
SOUTH AMERICAN IMPORTS			
High-income exporters	30.5	5.6	36.1
Low-income exporters	34.8	12.1	46.9

Figure 2 reports the distribution of shipping times into South America, separating direct connections from all shipping times. Two things are clear. One, it takes a long time to get to South America by boat, and two, the ability to use direct connections significantly speeds trade because indirect connections can require cargos to steam for weeks in the wrong direction[2].

[2] Shipping times may also be affected by cargo volumes and competition (or lack thereof) among international shipping lines. See also Hummels and Skiba (2002) and Hummels, Lugovskyy and Skiba (2008).

Figure 2
Ocean Transit Times to South America



Air Cargo is Less Common and Mode Mixing is Less Common

When using the U.S. data in 2007, we examined cases where the same exporter shipped goods via both air and ocean to the U.S. market and used information on the time saved (and additional expense incurred) with air freight to identify willingness to pay for timely delivery. In the South–South context, we can use this same approach to identify timeliness in some cases, but this is not a comprehensive solution. Relative to U.S. imports; it is much more common to see only a single transportation mode (only air, or only ocean) used by an exporter shipping to a particular destination.

Table 3 reports the share of air cargo in total imports for seven South American countries, disaggregated by exporting region. South American countries have lower air shares over all, and especially low air shares when purchasing from Africa. Air cargo use is most prominent when importing from higher-income exporters in North America and Europe. A consequence of lower aggregate use of air cargo is that there are fewer instances in which exporters employ both air and ocean cargo for shipping the same product. In total we see both modes used in about one-third of all South American trade flows.

Table 3
Air Cargo as a Share of Total Trade by Exporting Region and Importer

Exporting Region	Argentina	Brazil	Chile	Colombia	Ecuador	Paraguay	Peru
Africa	0.01	0.03	0.02	0.09	0.03	0.01	0.02
Asia	0.12	0.29	0.08	0.19	0.04	0.1	0.1
Australia and Oceania	0.16	0.07	0.09	0.15	0.08	0.33	0.06

Central America	0.38	0.05	0.12	0.33	0.19	0.24	0.17
Europe	0.28	0.27	0.21	0.38	0.26	0.23	0.25
North America	0.38	0.43	0.29	0.43	0.29	0.68	0.27
South America	0.15	0.12	0.17	0.16	0.13	0.11	0.06

ADAPTING METHODOLOGY TO SOUTH-SOUTH TRADE

Given the rarity of trade flows and of "mode mixing" in the South American dataset, the methodology for quantifying time-in-trade must be adapted to address a key question: could time delays cause some South–South exporters to trade certain commodities in diminished quantities? More importantly, could the time delays cause potential traders not to even try trading that good at all? Using a probability model as our methodological basis, we can begin to examine the role of time delays on trade and adapt the 2007 methodology to estimate the value of South-South time-in-trade. The sections below provide an overview of the adapted methodology—the detailed methodology is provided in an appendix.

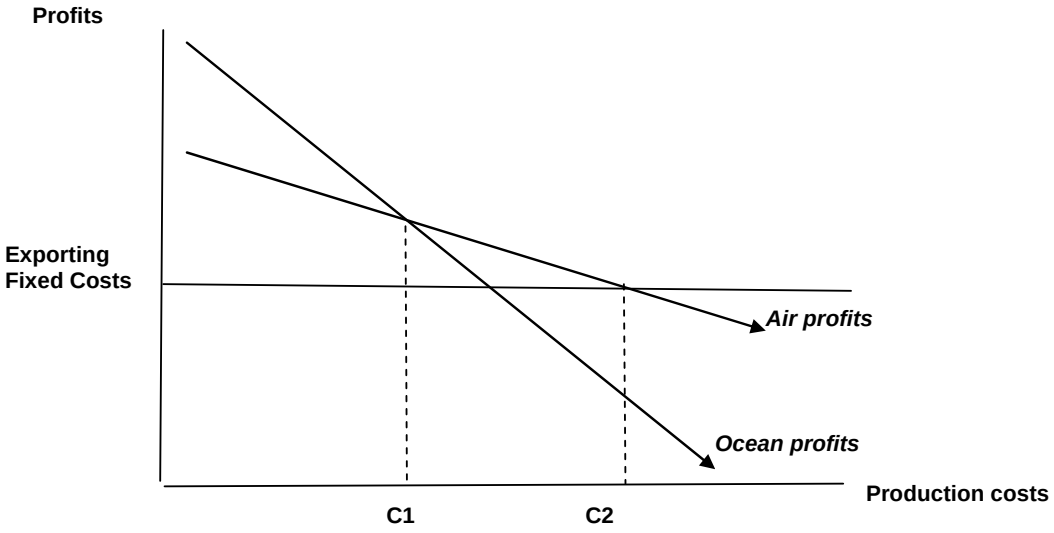
Underlying Assumptions

For our purposes, we define a "trade flow" as an observation on trade taking place for a given exporter x importer x HS6 product x time. For example, China's export of HS 830110, "padlocks of base metal", to Argentina in 2005 is a trade flow. For any given trade flow, there are three possible outcomes:

- Outcome #1: trade is observed using one transport mode (either ocean or air shipping)
- Outcome #2: trade is observed, and both air and ocean are used.
- Outcome #3: no trade is observed, so that the value of trade is zero.

To understand why these three outcomes are possible, consider a firm that wishes to engage in trade. This firm calculates the profitability of shipping goods by ocean or air, weighing the higher cost of air shipment against the benefit to buyers of goods that arrive more quickly. We summarize these decisions in Figure 3.

Figure 3
Exporter Profits



Profits for both modes are declining in production costs – the more expensive the good is to produce, the lower are the sales and the lower are profits.

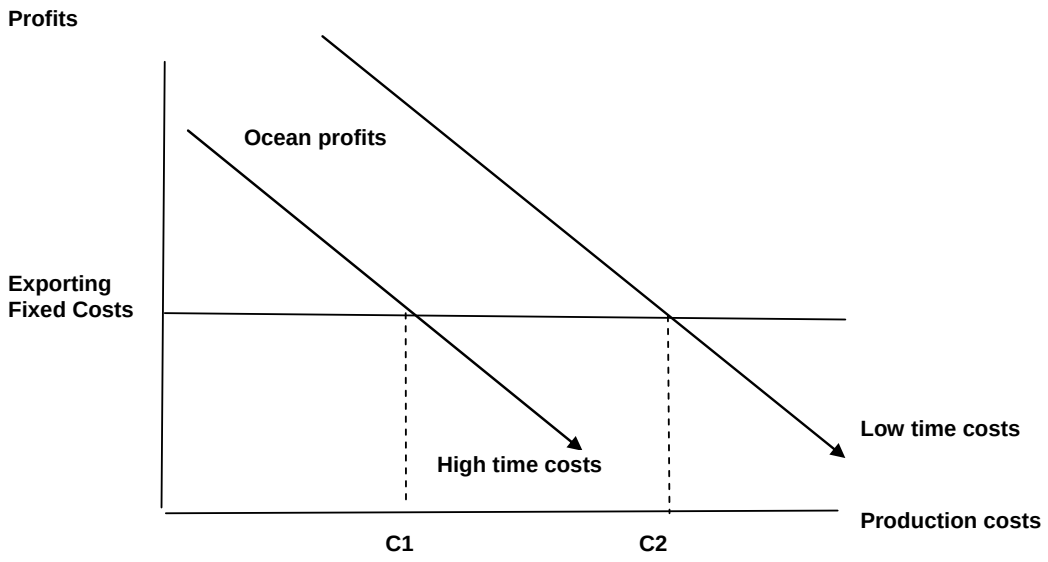
Note that the profits from ocean profits fall faster than air profits as prices rise. Why is this? Suppose the cost of air shipping a pair of shoes is $10 and the cost of ocean shipping is $1 per pair. If the shoes cost only $10 to produce, air shipping doubles the price of shoes, while ocean shipping increases it by only 10 percent. However, if the shoes cost $100 to produce, air shipping adds 10 percent to the cost and ocean shipping adds 1 percent. Buyers are sensitive to changes in the delivered price. When production costs are low (below C1 in Figure 3), air shipments significantly increase the delivered price and substantially reduce sales. In this case, the cost of saving time exceeds the benefit and ocean shipment is chosen. But when production costs are high (above C1) air shipments have a modest effect on delivered price and sales. Here, the added benefit of timely delivery exceeds the cost and air shipment is chosen.

Finally, to sell in a foreign market, firms must collect information about that market, set up distribution channels, market and perhaps customize their product. These fixed costs imply that firms will export only if they can generate sufficient revenue from sales to cover the fixed costs. If profitability is less than the fixed cost of exporting (to the right of C2 in Figure 3), no trade takes place.

Given this setup we can now understand the differences between the US market and the South American markets. The U.S. import market is vast, and so there will be many firms that find it worthwhile to pay these fixed entry costs and export. Outcome #3 (no trade takes place) is therefore rare. Some of these firms will have production costs below C1 (and choose ocean shipping) and some have production costs above C1 (and choose air shipping). In the national level trade data that aggregates over individual firms we very commonly see a mix of modes employed (Outcome #2).

Yet in our analysis of the South American importers there is an unusually high observation of Outcome #3—no trade at all. While a variety of factors may be involved, to what degree do time delays contribute to shutting off trade flows entirely? Exploring the answer to this question can affect our estimates of time costs even for those trade flows that do take place. To see why, we turn to Figure 4.

Figure 4
Selection: Ocean Profits with High and Low Time Costs



Here we suppose that air shipping is prohibitively expensive, and is always less profitable than ocean shipping. We now compare the profitability of ocean shipping in two cases. If time costs are high (either because goods are time sensitive or an exporter-importer pair is far apart) the delays associated with ocean shipping reduce sales and profitability significantly. If time costs are low (because the good is not time sensitive or the countries are nearby), however, then exporting is more profitable. Compare each to the fixed cost of exporting. The higher time costs are, the less likely we are to observe a trade flow taking place.

This discussion identifies two critical features of South–South trade that we must take into account when evaluating time costs. Ocean transit times are very long for South-South trade, which means that time costs will be especially large. Figure 4 suggests that these time costs will be manifested not by marginally lowering quantities of trade as in the US imports data, but by eliminating trade entirely in many products. The figure also suggests that we are more likely to observe a trade flow precisely when time costs are low. In other words, if we try to estimate the impact of time on trade looking only at observations where trade actually takes place, we will systematically underestimate the importance of time on trade overall.

In the detailed methodology appendix we describe how we account for these features in the data and specify the precise estimating equations employed.

Calculating Per Day Time Costs

Next we calculate per day time costs for trade flows that actually take place. This analysis proceeds in three steps.

1. Estimate the probability that a product is traded, and account for the possibility that the most time sensitive goods are “selected” out of the sample

2. Estimate per day time costs for each product, conditional on trade being observed.
3. Calculate the aggregate impact of per day time costs using information on the time cost per product and the importance of each product in trade.

Throughout, the reader should keep in mind that these are regression estimates. Because we are examining thousands of estimates, and in the interests of brevity, we focus only on statistically significant point estimates and do not report confidence intervals. Confidence intervals are available from the authors on request.

Step One: Estimate the Probability That a Product Is Traded

In Step One, we estimate how an increase in time to trade lowers the probability that a trade flow will be observed, in essence, narrowing the range of goods that a country can successfully export.[3] To predict the probability that a trade flow is positive, we use three pieces of information: the strength of comparative advantage for that exporter and product (measured by its exports to the world as a whole); the length of time it takes to move a good overland and through ports in the exporting country; and the ocean transit time between the importer and exporter.

Table 4 reports the estimated values pooling over all products. The marginal effect of exporter time to trade on the probability of observing trade is -0.0027. This means that a four day increase in time to trade lowers the probability of trading a particular good by 1 percentage point. Similarly, the marginal effect of ocean transit time is -0.0035. A three day increase in ocean transit time lowers the probability of observing trade by 1 percentage point. The consistency of these estimates is instructive: adding a day to trade has a similar effect on the likelihood of seeing trade whether it occurs inland, at the port, or on the ocean. Note that these estimates control for the size of the importing market and the strength of the exporter's comparative advantage in a particular product.

Table 4
Time and the Probability of Trade

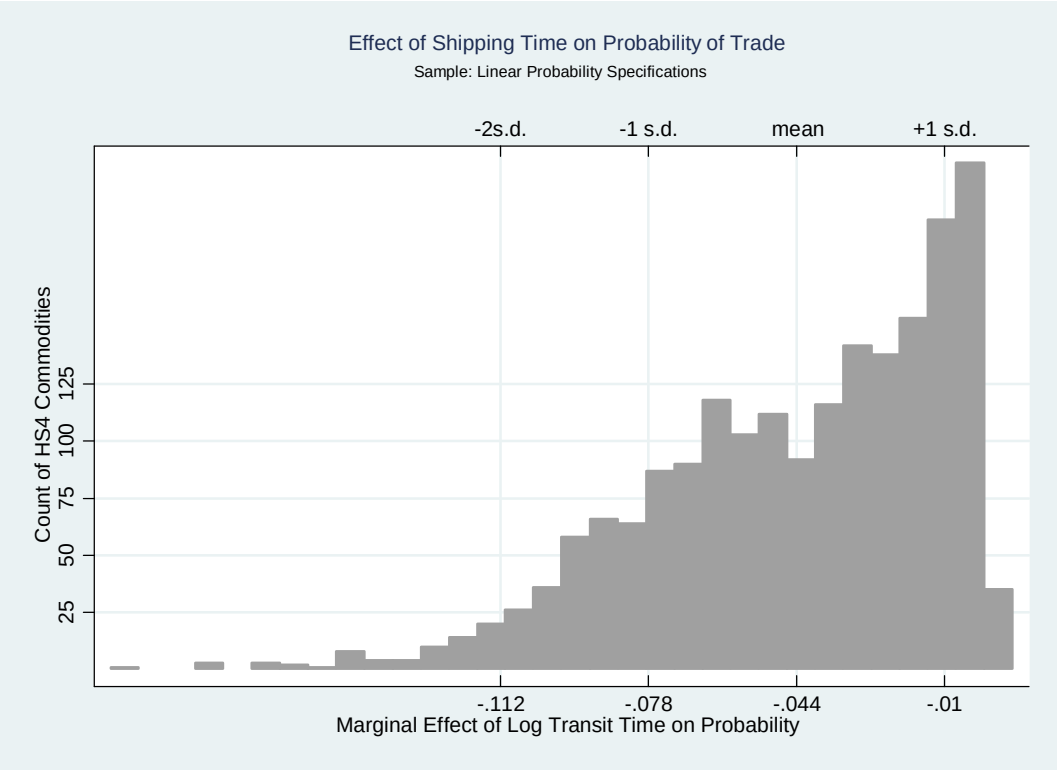
Exporter Time to Trade	-0.0027
Ocean Transit Time	-0.0035
Comparative Advantage	0.0114

Our finding that large time lags reduce a substantial number of trade flows from a positive quantity to zero is important for two reasons. First, it will be important to control for this effect when estimating per day time costs for trade flows that actually take place. Second, it suggests that time delays may help to explain why South-South trade consists of a fairly narrow export portfolio. We return to this point in Chapters 3 and 4.

[3] It is only possible to make this statement probabilistically. If we see a trade flow, we can infer that the profits from trade were above fixed costs, and if no trade flow takes place, we can infer that profits were below fixed costs. But in each case, we cannot tell exactly how far above or below fixed costs they were. The idea of a probability model is to estimate the likelihood that an increase in transit time pushes profits below fixed costs.

We next explore a subtle change in specification by using the log of transit time (rather than transit time in the number of days) and also estimate these effects separately for each product in order to see if transit times have a larger effect on some products than on others. The distribution of the effect is shown in Figure 5, and for ease of display is produced in elasticity form. For the mean good, the elasticity is -0.044, meaning that doubling the time to trade reduces the probability of a trade flow occurring by 4.4 percent. Further, there is significant variation across products in this estimated effect.

Figure 5
Time and the Probability of Trade—Differences across Products



Step Two: Estimate Per Day Time Costs For Each Product

In Step Two we estimate per day time costs for each product, accounting (via an econometric method known as a Heckman selection correction) for the possibility that the most time sensitive goods are selected out of the sample. We employ two samples.

The first sample is similar to that used in Hummels/USAID (2007) but using South American imports rather than US imports. Here the data sample includes only trade flows where both air and ocean shipments are used by the exporter. We call this our "relative value sample" because it examines the value of air shipments relative to ocean shipments in a trade flow as a function of the air cargo premium (the cost of timely delivery) and the time delays associated with ocean shipping. Combining these estimates yields the value to buyers of saving a day in transit that is specific to each product *k*. We call this time value τ^k .

The second sample examines cases where only one transport mode is used. We call this our "probability sample" because it examines the probability that air shipments take place (i.e. are firms to the right or the left of point C1 in Figure 2) as a function of relative freight costs and ocean transit times. These methods and their dependent variables differ because of the need to adapt methodologically to the peculiarities of the South American import data. The interpretation of the regressions, however, is very similar, and both yield an estimate of the per-day cost.

In both cases, we provide a selection correction to address the problem that extremely time-sensitive goods may be gone from the samples.

Figure 6 below lists several examples of time estimates time estimates for specific goods. These goods were chosen to correspond as closely as possible to those presented in the 2007 USAID-funded time-in-trade research.

Figure 6

Illustrative Time Estimates for Specific Goods

Description	Share in World Trade (%)	Tariff Equivalent for Value of Time Saving Per Day (%)		
		U.S. Imports	South America, All Categories*	South America, Significant Estimates Only**
Road vehicles (including air-cushion vehicles)	7	2	0.01	0.4
Coffee, tea, cocoa, spices, and manufactures thereof	0.5	1.1	0.6	1.5
Telecom, sound recording and reproduction app and equip.	4.4	0.9	0.3	0.7
Vegetables and fruit	1.3	0.9	0.7	1.4
Motor vehicle parts	2.4	0.8	0.4	0.4
Cereals and cereal preparations	0.9	0.8	0.5	1.2
Articles of apparel and clothing accessories	3.7	0.7	0.1	0.4
Power generating machinery and equipment	2.6	0.6	0.3	0.5
Textile yarn, fabrics, made-up articles, n.e.s.	2.3	0.6	0.3	0.7
Office machines and automatic data processing machines	5.4	0.5	0.4	1
Medicinal and pharmaceutical products	2.9	0.3	0.06	0.1
Footwear	0.8	0.2	0.01	1.3
Crude oil	5.9	--	0	0
Coal, coke and briquettes	0.5	--	0	0
Fertilizers (except crude of Group 272)	0.1	--	0.07	0.9
All others	60		0.4	0.7

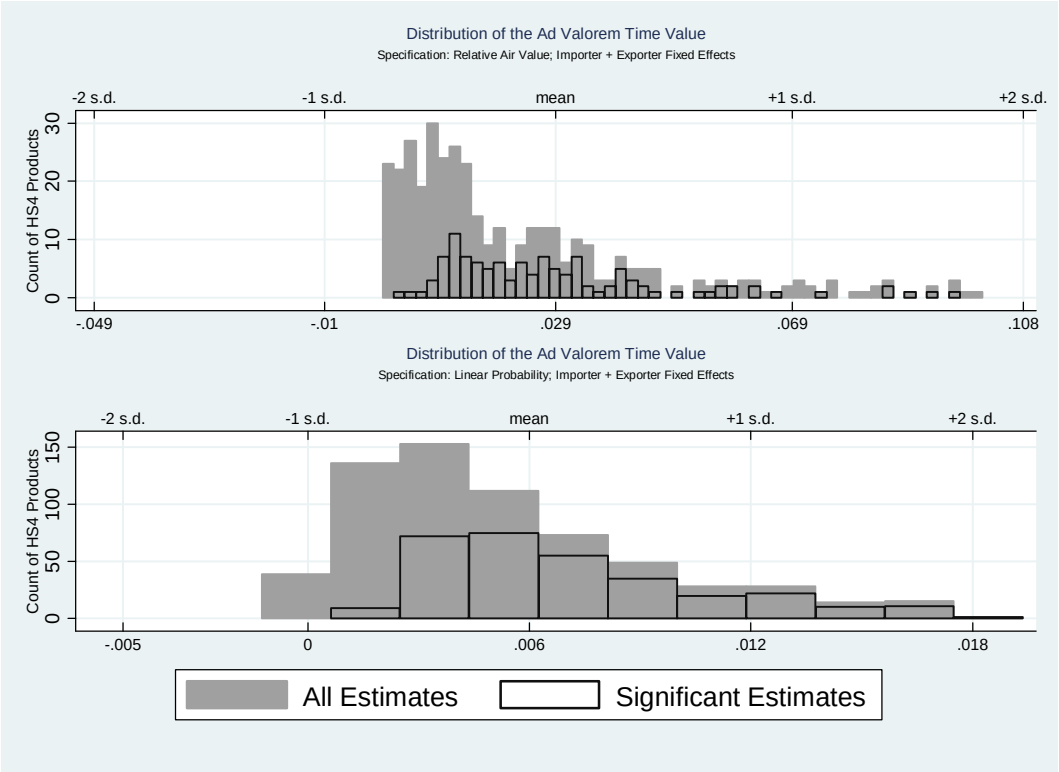
** In this column we treat all HS4 product lines in which we are not able to estimate time effects as having a value of zero*

*** In this column we drop HS4 product lines in which we are not able to estimate time effects, and then construct weighted averages of the remaining HS4 lines*

For our purposes, given the necessary adjustments to methodology for the 2010 South-South work, the next figure (Figure 7) provides a systematic picture of how the estimates look across all the products. Figure 7 reports the distribution of time cost estimates in the two samples. The grey shaded histogram includes all positive estimates. The outlined histogram reports only the positive estimates that are statistically significant. We see two things from these pictures. One, there is a wide range of estimated time costs. Two, time costs are much larger in the relative value sample than in the probability sample. The mean estimate in the relative value sample, $\overline{\tau} = .029$ is almost five times larger than in the probability sample $\overline{\tau} = .006$. For comparison, the average time value estimated in Hummels/USAID (2007) using US data was $\overline{\tau} = .008$. This implied that each day in transit was equivalent to 0.8 percent of the good's value, so that a five-day delay was equivalent to a 4 percent ad-valorem tariff.

What explains the difference between the relative value sample and the probability sample? Put simply, for a product to be in the relative value sample, it must be sufficiently time sensitive that at least some shipments use very expensive air cargo. Meanwhile, goods in the probability sample may be shipped using only ocean cargo precisely because the goods are less sensitive to the long delays in ocean shipping.

Figure 7
Distribution of Time Cost Estimates



Step Three: Calculate Tariff Equivalents of Per Day Time Costs

In Step Three, we take estimates of per-day time costs that are specific to each product and aggregate them. The large variation across products in time sensitivity imply that differences in the product composition of trade for a particular exporter or importer-exporter pair can lead to large differences in the importance of time costs. This aggregation can be done in a variety of ways. We provide three weighting schemes.

The first, like Hummels/USAID (2007) corresponds to the importance of product *k* in worldwide trade for exporter *j*. The weights correspond to the value share of product *k* in exports for a given exporter *j*.

$$\tau_j = \sum_k s_j^k \tau^k$$

The second corresponds to the importance of product *k* only in trade with the South American countries in our sample. The third uses weights specific to each country pair so that we have, for example, the time costs applied to Argentine imports from African exporters. If a given exporter ships the same mix of commodities to Argentina as it does to South America as a whole and to the world as a whole, then the aggregated time cost will look the same in each case. However, the aggregated time cost will look different if the commodity mix looks different. For example, if a South Asian exporter ships only those goods with low time sensitivity to Argentina while

shipping goods with high time sensitivity to the rest of the world, then the aggregate time cost for South Asia–Argentine trade will be lower.

These values are available on request for each exporter. For simplicity we average them for eight broad regional exporting groups, and report them in percentage or ad-valorem terms (so that a $\bar{\tau} = .004$ is written as 0.40 and corresponds to a 0.4% tariff. Table 5reports estimates using the probability regressions and Table 6 reports the results using the relative value regressions.

Table 5

Per Day Time Costs: Probability Sample

Exporting Region	World	South America	Argentina	Brazil	Chile	Colombia	Ecuador	Peru
World	0.42	0.32	0.37	0.38	0.39	0.39	0.35	0.4
High Income: OECD	0.44	0.38	0.41	0.4	0.4	0.43	0.39	0.39
South Asia	0.29	0.23	0.26	0.26	0.19	0.17	0.17	0.18
Latin America & Caribbean	0.43	0.31	0.29	0.3	0.42	0.33	0.31	0.46
Europe & Central Asia	0.41	0.28	0.41	0.31	0.35	0.21	0.08	0.25
Middle East & North Africa	0.55	0.27	0.48	0.24	0.38	0.56	0.4	0.45
East Asia & Pacific	0.43	0.36	0.35	0.43	0.25	0.28	0.31	0.28
Sub-Saharan Africa	0.54	0.33	0.21	0.23	0.35	0.68	0.47	0.34

Table 6

Per Day Time Costs: Share (Relative Value) Sample

Exporting Region	World	South America	Argentina	Brazil	Chile	Colombia	Ecuador	Peru
World	1.08	0.82	0.68	0.96	0.76	0.7	0.71	0.69
High Income: OECD	0.82	1.00	0.78	1.01	0.82	0.72	0.81	0.75
South Asia	1.04	0.36	0.4	0.44	0.27	0.18	0.34	0.34
Latin America & Caribbean	1.13	0.63	0.49	0.49	0.68	0.59	0.57	0.62

Europe & Central Asia	0.75	1.67	0.96	1.21	1.21	1.68	1.87	1.36
Middle East & North Africa	0.79	0.59	0.99	1.96	0.55	1.11	0.41	0.75
East Asia & Pacific	0.76	0.72	0.52	0.86	0.51	0.57	0.63	0.52
Sub-Saharan Africa	2.61	1.50	1.02	0.48	0.61	3.1	0.19	0.96

In our probability sample using world weights, per-day time costs range from 0.29 to 0.55 and average to 0.42 percent. That is, each day in transit is equivalent to a 0.42 percent tariff. These numbers are systematically smaller than the share sample, which ranges from 0.75 to 2.61 and has a worldwide average of 1.08.[4] The estimated time costs in the relative value sample are actually larger than were found in the Hummels/USAID (2007) paper that used U.S. imports, while the time costs in the probability sample are much smaller. Why? Products are in the relative value sample only if they are sufficiently time sensitive to merit the use of air cargo. Other products, with lower time sensitivity, appear only in the probability sample. The probability sample is therefore more representative of South American imports as a whole, and time costs here are roughly half of what was found for U.S. imports.

There is an additional important finding in Table 5 that can be seen by comparing world trade weights with South American imports weights. In the latter case we find systematically lower numbers in the probability samples across all exporting regions. Why? As we explore below, the time it takes to trade with southern countries is much longer than with the North. This means that the most time-sensitive products that an exporter trades with the rest of the world never make the profitability cutoff for South American trade. The most time-sensitive goods simply disappear from the trade bundle. This effect is especially pronounced for southern exporters

[4] The difference between the relative value and probability samples are much smaller here than is seen in Figure 6. The reason is that Figure 6 gives an equal weight to all product codes whereas these tables weight products by their share in trade. This suggests that the large differences in Figure 6 are driven by outlier products that represent a small share in trade.

3. Discussion

Based on the results of our research using the ALADI dataset, we can begin to revisit the questions posed in the introduction to this paper. Our research highlights three key aspects of South-South trade vs. the overall trade flows addressed in the Hummels/USAID study from 2007:

1. US importers value time in trade more than South American importers.
2. Nevertheless, the aggregate impact of delays on South-South trade is actually larger than US trade because
    - Transit times for South-South trade are much longer than for US imports
    - The cost of avoiding delays is higher for South-South trade
3. Time delays not only reduce the quantity of South-South trade, they reduce the likelihood that trade flows take place at all. This affects Southern countries' ability to diversify exports.

US IMPORTERS VALUE TIME MORE THAN SOUTH AMERICAN IMPORTERS

Conditional on trade taking place, South American buyers value a day saved at 0.42 percent ad-valorem, or roughly half the value for US buyers estimated in Hummels/Nathan (2007). Why do US importers value time in trade more than South American importers? Some insights may be gained in looking at the composition of South-South trade, timeliness as a luxury, price and quality of the goods being traded, and organization of production.

Composition of South-South Trade

Broad categories of goods have different time sensitivity. Figure 5 in the previous chapter makes clear that there are very large differences across products in their time sensitivity, ranging from zero up to 2 percent ad-valorem per day in the probability samples.[5] Because of these differences, the aggregate impact of time delays on the economy depends on what goods a nation trades. The broad commodity composition of South–South trade is quite different than North–North or North–South trade, implying different aggregate sensitivity. For example, focusing on the South

[5] A similar pattern was found in Table 2-2 of Hummels/Nathan (2007). It showed that simple manufactures such as footwear show modest degrees of time sensitivity—buyers treat an extra day in transit as a cost equivalent to a 0.2 percent ad valorem tariff. Complex manufactures such as cars are 10 times more time sensitive, with buyers treating an extra day in transit as equivalent to a 2 percent ad valorem tariff. Apart from manufactures, some bulk commodities (fertilizers, coal, oil) exhibit no time sensitivity, while vegetables and fruits are highly time sensitive.

America column of Table 5 we see that the average time cost (0.32 for the world as a whole) incorporates costs as high as 0.38 for high income OECD exporters and as low as 0.23 for South Asian exporters. These differences are due entirely to product composition differences across the regions.

The composition of trade across broad product groups is not the only difference between US imports and South-South trade. We next explore reasons that any particular product may be more time sensitive when imported by the US than by South America.

Timeliness as a Luxury

The fundamental insight of the Hummels (2001) and Hummels and Schaur (2010) work is that buyers value timeliness in the same way that they value higher-quality goods. It then follows that demands for timeliness, like demands for higher-quality products, may be responsive to income differences. The Hummels/USAID (2007) paper focused on U.S. imports, and the higher income of U.S. consumers may then be reflected in greater time sensitivity for trade. South-South trade, involving lower-income consumers, may exhibit lower degrees of time sensitivity as buyers opt for slow-arriving and therefore less-expensive products. If a buyer cares less about late-arriving goods, then customs and shipment delays impose lower costs on that buyer.

Price and Quality of Goods

New research emphasizes large differences in the price and quality of traded goods even in narrowly defined product categories such as cars or footwear. For many goods there is a systematic relationship between product prices and the income level of the exporter and the importer.[6] High-income exporters specialize in higher-quality market segments and therefore sell higher-priced goods, while low-income exporters specialize in lower-quality, lower-priced market segments. The same pattern appears on the buying end, as higher income translates into the purchase of higher-priced goods. A consequence is that the composition of South–South trade, defined in terms of product price and quality, may be significantly different, even in a single category of goods such as footwear.

This matters for timeliness in two instances. One, timeliness may be complementary to product quality. The higher the quality of the product the more buyers insist on rapid arrival. This would be especially relevant if quality reflects cutting edge characteristics that rapidly obsolesce. Two, product prices have a profound effect on shipping prices and the cost of purchasing timely shipment. Let's revisit the "shoes" example from Chapter 2, contextualizing it within South-South trade. Suppose the cost of air shipping a pair of shoes is $10 and the cost of ocean shipping is $1 per pair. A Brazilian buyer wishes to purchase a $10 pair of shoes from China. The air shipping cost doubles the price of shoes, while the ocean shipping price increases it by only 10 percent. Contrast this with a U.S. buyer who wishes to purchase a $100 pair of Italian shoes and faces the same shipping prices. Air shipping adds 10 percent to the cost; ocean shipping adds 1 percent.

[6] Schott 2004 and Hummels-Klenow 2005 provide evidence on exporter incomes and variation in export prices. Hallak 2006 and Choi et al 2009 provide evidence on importer incomes and the import prices.

This simple example carries two implications. First, the ad valorem cost of shipping goods is significantly higher for low-income countries. Hummels, Lugovskyy, and Skiba (2009) estimate this effect, comparing shipping costs for high and low income countries using the US imports data sample employed in Hummels/USAID (2007) and the South American imports data sample employed here. They find that for a given HS product category, ad-valorem shipping costs in US imports were 41 percent higher for non-OECD countries relative to OECD countries, most of which was due to differences in product prices. Latin American imports experienced 30 percent higher shipping costs than US imports, and within Latin American imports, non-OECD countries 40 percent more than OECD countries. Again, these comparisons are within product categories, and the main driving force is differences in product prices. Putting that all together, shipping costs for South-South trade are more than double shipping costs for North-North trade--with the main difference being product prices.

The second implication is that the premium paid to ship goods by air—measured relative to the value of goods being shipped—will also be substantially higher for South-South trade partners. That is to say, one can purchase timely delivery anywhere in the world, but purchasing timely delivery is much more expensive for South–South trade partners. Focusing on the South American imports data used in our sample, the air shipping premium is 25 percent higher when the exporting country is in World Bank's "Low Income" country grouping.

Organization of Production

The value of timeliness depends not just on what is produced and who consumes it, but on how production is organized. Follow-up work on time sensitivity in U.S. trade by Hummels and Schaur (2010a, 2010b) has begun to reveal some of what explains the variation in time sensitivity across products.

Hummels and Schaur (2010a) find that a significant motivation for air shipping goods is to hedge volatile demand. Purchasing goods from distant locations introduces a significant lag between when a product is shipped and when it arrives. These transit lags are trade barriers for firms facing volatile demand that must place orders before knowing the resolution of demand uncertainty. Fast transport, in the form of timely air shipment, allows firms to respond quickly to favorable demand conditions and to limit the risk of unprofitably large quantities during low demand periods. They show that an increase in uncertainty about import market conditions will push more firms to value timely delivery. If South–South trade is subject to different degrees of uncertainty than U.S. trade, the resulting demand for timeliness should also vary.

Hummels and Schaur (2010b) find that intermediate inputs exhibit higher time sensitivity than final consumer products. If firms produce final goods for sale in one geographically concentrated region, there are small distance and time penalties attached to moving intermediate inputs between stages of production. However, if firms fragment production so that value is added around the globe before final assembly in a location, timely delivery becomes much more important. A component that arrives late can shut down an entire assembly line. This suggests that time sensitivity depends not just on buyers' preferences for fast-arriving goods, but on the organization of production. It is well known that U.S. production is increasingly fragmented, and this may explain the high degree of time sensitivity found in the earlier work. If South–South

trade is not characterized by fragmented production to the same degree, the same products may be much less time sensitive.

SOUTH-SOUTH TRADE PER-DAY TIME COSTS ARE LOWER, BUT TOTAL IMPACT OF TIME IS GREATER

The choices made by trading partners depend on the opportunities available to them. Mexican manufacturing firms ship quickly and inexpensively to the United States via truck. This is an option open to them, and not to South American or African firms, by virtue of geography. Similarly, the large volume of U.S. imports, and the intensity of competition between many shipping lines offering service to the United States from European and Asian ports, results in ocean shipping connections that are direct and fast. South–South trade is characterized by low volumes, poor service connectivity between countries, and long travel times.

From Table 2, the average shipping time to our South American importers from low income exporters is five weeks, and nearly seven weeks once we include inland times. In contrast, average shipping times to the US by boat are less than four weeks, and perhaps only a few days from Canada and Mexico (representing 27 percent of US imports in 2010). In short, while US buyers value place double the value per day on time, the time delays they face are roughly half as long.

Further, as noted above, the ad-valorem cost of shipping is much higher for South-South trade and the relative cost of purchasing air shipping is higher still. Not only are time delays much longer for South-South trade, they are much more expensive to avoid by using air shipping.

TIME COSTS SHUT OFF SOUTH–SOUTH TRADE ENTIRELY

Our research shows that an important effect of time delays is not only to cause South–South country pairs to trade a product in diminished quantities, but also not to trade a product at all. This may help explain why South–South trade is characterized not just by lower quantities of trade, but by a smaller and less diversified set of traded goods. Hummels-Klenow (2005) show that Southern exporters have smaller and less diversified trade bundle than do Northern exporters. Their widely adopted measure of the size of the export bundle, called the extensive margin of trade,[7] is highly correlated with exporter size and income. Doubling income per capita causes an 85 percent increase in the size of the export bundle.

Let's revisit Table 1 from the introduction to our report. Even for those country pairs with some trade, the trade bundles are remarkably narrow. At this level of aggregation (HS 6 products) there are 4,998 products represented at least once in our data. We next calculate how many distinct goods each South American importer buys from exporters with whom there is some positive trade. When importing from the OECD each country buys hundreds of products on average (660 for Brazil). When buying from Sub Saharan Africa, these South American countries buy between 0.4 and 4.5 products.

[7] The extensive margin of trade includes both the number of products and number of trade partners, weighted by the importance of each good and partner in world trade.

Consider the following rough calculation. Table 4 indicates that a one day increase in time to trade lowers the probability that trade occurs in a particular product by 0.35 percent. The difference between “North-North” and “South-South” trade in Table 2 is 19.3 days, which translates into a 6.7 percent lower probability that trade occurs in any particular product.

Put another way, suppose we have a country pair with an average South-South trade time who are trading 1,000 HS6 products. We then manage to reduce their trading time by 19.3 days to the North-North average. We would expect them to now trade 67 more products. Note that our estimates are conditional upon an exporter’s existing comparative advantage, that is, on its success in exporting products to at least one other market in the world. The calculation then refers to the ability to find a wider geographic diversity of destination markets as opposed to shifting into a wholly new and different product line.

Of course, this calculation is meant to be illustrative and would require significant refinement to be directly applied. Figure 5 suggests large differences across products in the degree to which increased time to trade lowers the probability of trade. Reducing time in trade may have a more profound effect on some categories of goods but not others. Related, and recalling Figure 3 from the methodological chapter, a particular country pair may be relatively near to or far from the threshold level of profitability necessary for trade to take place.

Our simple calculation provides the average change in the probability in trade, but could be refined to assess how close any particular country pair is to the profitability threshold and whether a reduction in time to trade would tip them over that threshold.8

[8] In technical terms, the marginal effects reported in Table 3 and Figure 4 assess the impact of changing time on the probability of trade, conditioning on the average value of other variables. A particular country pair and product will have different values for these conditioning variables and so be closer to or farther away from profitability.

4. Conclusion/Next Steps

The application of the 2007 time-in-trade methodology to the South American imports data in the ALADI dataset reveals a significant difference in the degree to which the US (and by extension other “Northern” countries) and the developing world value time-in-trade. As reported earlier, South-South time-in-trade values are roughly one half of Northern time values; in other words, developing countries appear to value expedited trade significantly less than their Northern counterparts. This may be attributed to several characteristics of South-South trade: (1) the goods being traded are of a lower price and quality and consequently (2) importers are unwilling to pay the premium to have them shipped faster (air vs. ship). Low income levels in developing countries play a major role in both of these factors.

IMPLICATIONS FOR PROGRAMMING AND FURTHER RESEARCH

As in 2007, this 2010-2011 research can generate important discussion research on the role of time-in-trade. While there are many factors involved, a reasonable assumption from this research is that to increase South-South trade, one needs a larger reduction in time delays than trade with richer countries. This may appear daunting, however, given the large time delays currently, there is a lot of room to move up here and improve. USAID-funded trade capacity building projects—with their focuses on supporting greater regional integration, streamlining and harmonizing customs and logistics procedures, and improving the efficiency of transport corridors (as expressed by reductions in time and cost) are helping host country public and private sector actors to facilitate trade and close the time gap.

The current research also reinforces the positive relationship between export diversification and economic growth, and poses intriguing questions worthy of further study. The highly undiversified trade bundles that emerge from the current research (as described in Chapter 2) are a puzzle. The estimates in Table 4 and the data on time to trade shown in Table 2 suggest that the extraordinarily long time to trade may be an important piece in understanding this phenomenon. Let’s revisit that South-South country pair in Chapter 3 that chooses to entirely shut off trade of a specific product, because it is unprofitable. Further refinements to the South-South research begun here could pose—and potentially answer—interesting questions regarding thresholds for trade. In other words, a particular country pair may be relatively near to or far from the threshold level of profitability necessary for trade to take place.

While our calculation provides the average change in the probability in trade, it could also be refined to assess how close any particular country pair is to the profitability threshold and

whether a reduction in time to trade would tip them over that threshold. Having this information could be a valuable metric from which to design future donor-funded programming in export promotion/competitiveness, or to amend ongoing programs. Such a calculation could help USAID and developing country partners make informed decisions about the level of support required to increase the competitiveness of given products exported to specific markets—both Northern and Southern.

In March 2011, Dr. David Hummels presented initial results of the South-South time in trade research for an audience of key players from the USAID Economic Growth team. The presentation generated a lively discussion about the application of the South-South data to the 2007 methodology and the team was particularly interested in how the results could be used to provide a new quantitative basis of measurement for trade capacity building programs. The research presented in this paper represents only the beginning of what is possible; TCBoost looks forward to discussing with USAID the possibility of continuing this research on this or a future USAID-funded project.

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Appendix. Detailed Methodology and Data

In this section we describe the data used in the empirical exercises, provide a model for interpreting these data, and an econometric methodology for estimation.

For a given trade flow, there are three possible outcomes

1. Trade is observed using one transport mode (either ocean or air shipping)
2. Trade is observed, and both air and ocean are used.
3. No trade is observed, that is the trade flow is a zero value.

We wish to explain all three cases, and describe how to calculate the value of time savings in each case. Following Hummels and Schaur (2010b), we describe import demand facing products sold by an individual firm as

$$(1) \qquad q = E\left(\frac{p}{\nu \exp(-\tau \cdot days)}\right)^{-\sigma}$$

Where q is demand, p is price, E is real expenditure on a related category of products, and σ is the elasticity of substitution between goods. The denominator $\nu \exp(-\tau \cdot days)$ is a price-equivalent demand shifter corresponding to the shift between points A and C in Figure 1. It includes product quality ν, and a term $\exp(-\tau \cdot days)$ that captures the buyer disutility of slow delivery. Time in transit, $days$, depends on exporter location because of differences in distance to the import market and infrastructure quality, but also depends on the endogenous choice of the firm to pay a premium for timely delivery.

Other things equal, a buyer gets more utility from a good that arrives sooner rather than later, which is expressed by increasing demand for that good. A 1% price reduction raises demand by σ %, and a 1 day reduction in delivery times raises demand by $\sigma\tau$. That is, the time valuation parameter τ translates days of delay into a price (or tariff) equivalent form, and the elasticity of substitution σ translates this into the quantity of lost sales.

The firm's marginal cost of delivering a product to the market via mode m=air,ocean is $c + g^m$, where c is the marginal cost of production and g^m is a per unit shipping charge that depends on the mode chosen.

Air shipping is more expensive than ocean shipping. Finally, there is a fixed exporting cost F that plays an important role in the analysis. To sell in a foreign market, firms must collect information about that market, set up distribution channels, market and perhaps customize their product. These fixed costs imply that firms will only export if they can generate sufficient revenue from sales to cover the fixed costs.

The firm charges prices that are a markup $1/\theta = \sigma/(\sigma - 1)$ over marginal costs. Their profits net of fixed costs of exporting are

$$(2) \qquad \pi^m = \frac{(c+g^m)}{\sigma - 1} E\left(\frac{(c+g^m)/\theta}{\nu \exp(-\tau \cdot days^m)} \right)^{-\sigma} - F$$

The firm can now compare the profitability of air versus ocean shipping as a function of the price premium paid for air delivery and the buyer preference to avoid delays associated with ocean delivery. The firm chooses air if $\pi^{air} > \pi^{ocean}$. Assume that any location can be reached by one day via air cargo, taking logs of (2) and simplifying we have

$$(3) \quad (1-\sigma)\left[\ln(c+g^{air}) - \ln(c+g^{ocean})\right] + \sigma\tau\left[days^{ocean} - 1\right] > 0$$

Equation (3) states that a firm trades the greater expense of air shipping against the improved "quality" of a product that arrives $days^{ocean}$ earlier. Long ocean shipping times are more likely to induce a switch to air shipping when buyers attach greater value to timeliness, and when goods are closer substitutes.

This relationship is shown in Figure 2, which graphs the profitability (before fixed costs) of each mode against the marginal cost of production.[9] These lines slope downwards because, as marginal costs (and therefore prices) rise, firm sales and profitability fall.[10] At some point, profits drop below the fixed cost of serving the market and firms will choose not to engage in trade.

Note that profitability drops at different rates depending on transportation mode. The reason is that while air shipping is always more expensive than ocean shipping, the effect of the air premium on delivered prices gets smaller as goods prices rise.[11] Recall the example from the introduction in which air shipping costs for a pair of shoes are $10 and ocean shipping costs are $1 per pair. When applying these costs to a $10 pair of shoes, the relative price of air shipped / ocean shipped shoes is 21/11, a 91% premium. For a firm selling $10 shoes, the air premium is prohibitive. When applied to a $100 pair of shoes, the air shipping increases the relative price by only 9% (110/101). While air shipping still raises prices relative to ocean shipping, it buys buyers rapid delivery. For buyers who value timeliness they will prefer the air shipped good.

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[9] All variables are in natural logs, as in equation (3) so that the resulting curves are linear.

[10] The firm faces a price elasticity of demand sigma > 1, so that a 1% rise in prices induces a more than 1% fall in quantities sold and declining revenue. For example, if sigma=5, a 1% rise in prices yields a 5% fall in quantities sold and a 4% fall in revenue.

[11] This is a consequence of assuming that shipping costs are proportional to the quantity shipped rather than the value shipped (see Hummels and Skiba 2004 for evidence strongly justifying this assumption.

To complete the analysis, consider the three cases corresponding to the outcomes found in the data.

1. Trade is observed in one transport mode
   A. **Ocean shipping.** This is seen in Figure 2 to the left of point C1, where profitability from ocean shipping exceeds profitability from air shipping.
   B. **Air shipping.** This is show in Figure 2 at costs between C1 and C2, where profitability from air shipping exceeds profitability from ocean shipping.
2. **Trade is observed, and both air and ocean are used.** Our data aggregate over all shipments of a particular product from an exporter in a year. Suppose that an exporter has two types of firms, the first of which has costs to the left of C1 and the second between C1 and C2. In this case, both transport modes will appear in the data. Similarly, we may be observing the same firm facing different production and/or transportation costs at different times during the year, and changing transportation modes on that basis.
3. **No trade is observed.** These are cases where the air and ocean profit lines are below the fixed costs of trade (to the right of C2). This could occur because an exporter was a high cost producer of the good, because transportation costs or time lags were high, or because fixed costs of trade are high.

We can consider these cases in three distinct empirical exercises. The first estimates the probability that air or ocean shipping is chosen. The second estimates the share of air relative to ocean shipping. The third estimates the probability that no trade takes place.

PROBIT ESTIMATION: PROBABILITY OF CHOOSING AIR SHIPPING

Suppose that all firms producing a particular good in location j have the same marginal cost of production. Then the value of the inequality in (3) is the same for all firms, and all choose the same mode. We can transform Equation (3) to replace unobservable marginal costs with ad valorem transport costs $f^m = \left(1 + g^m / p\right) > 1$. [12] The firm will choose air shipping if

$$(4) \qquad (1-\sigma)\left(\ln f^{air} - \ln f^{ocean}\right) - \sigma\tau\left(days^{ocean} - 1\right) > 0$$

For any particular trade flow either air or ocean is chosen. But the value of equation (4) will vary as we look at different exporter x importer x time trade flows because these trade flows differ in the relative cost of air and ocean shipping and in the time delay associated with ocean shipping. We can then use a probit model to estimate the probability that air or ocean shipping is employed, and exploit variation across exporters and over time in the 1,0 modal choice described in equation (4) to identify the elasticity of substitution σ and the time parameter, τ.

[12] This assumes the markups over total delivered costs are a constant and then uses the property that $\ln(c + g^{Air}) - \ln(c + g^{Ocean}) = \ln f^{Air} - \ln f^{ocean}$

MODAL SHARE ESTIMATION

Suppose that there are two types of firms, differing in marginal costs and/or facing different shipping costs. In this case we can express the ratio of export value by firms of the two types

$$\text{(5)} \qquad \ln \frac{p^{air} q^{air}}{p^{ocean} q^{ocean}} = (1-\sigma)\ln\left(\frac{p^{air}}{p^{ocean}}\right) + \sigma \ln\left(\frac{v^{air}}{v^{ocean}}\right) - \sigma \ln\left(\frac{f^{air}}{f^{ocean}}\right) + \sigma\tau \cdot \left(days^{ocean} - 1\right)$$

This is similar to the probit equation (4), except that it contains extra terms expressing differences in fob prices and qualities between firms employing air and ocean shipping. That is, the revenues generated by firms using air delivery will be higher because of buyer valuation of rapid shipping, lower because air transport raises delivered prices, and may be higher or lower depending on the extent to which quality adjusted prices vary across the two types. We can then use equation (5) and exploit variation in the relative air share across exporter x importers x time to identify σ and τ. That is, we will read the coefficient on relative freight prices as $\hat{\sigma}$ and the coefficient on days as $\hat{\sigma}\hat{\tau}$, so that the ratio of these coefficients yields $\hat{\tau}$. The share approach provides three compelling advantages: we directly observe shipping costs; we can provide better controls for unobserved product quality variation; and we can exploit information on quantities shipped to better describe the valuation attached to timeliness by buyers.

SELECTION

Firms will only export if profits net of fixed costs are positive. It must then be the case that, for the most profitable transport mode, profits from exporting exceed fixed costs, or

$$\text{(6)} \qquad (1-\sigma)\ln(c+g^m) + \sigma \ln v - \sigma\tau \cdot days^m - \ln F > 0$$

This defines a selection equation indicating whether or not a particular location successfully exports a product to the importer. A related problem has motivated several authors (e.g. Helpman, Melitz, Rubinstein 2008) to describe variables that represent entry costs, and to use these in a selection equation to predict whether there exists trade in any good between two countries. We are interested in selection operating at a much lower level, whether a particular exporter ships a product (defined at the HS6 level) to a South American importer at time t.

In order to estimate selection we need variables that predict the profitability of a trade flow, and each variable must be observed whether a trade flow is positive or zero. Suppose an exporter has a comparative advantage in a product, producing it at low cost and/or with high quality. This will be revealed in the value of that country's exports to markets worldwide. Simply, if Germany has high volumes of machine tools exports to the rest of the world, it is more likely that machine tool exports to South America will be sufficiently profitable to exceed fixed costs of trade. We then use rest of world exports as measures of latent variables $(1-\sigma)\ln(c+g^m) + \sigma \ln v$. To measure shipping time we use two variables. The first is the ocean shipping time between the importer and the exporter. The second is the time to trade variables taken from the Doing Business data.

These estimates provide us with two pieces of information. First, we can calculate how time delays affect the probability of a shipment occurring. Second, they can improve our estimates of the cost of time delays in the probit and share regressions. To explain this second point, note that the probit and share regressions are applied only on those trade flows with positive values. That is, if exporter profits are lower than the fixed costs of trade, no trade occurs to used in the probit and share specification. These unprofitable trades do not occur randomly. Rather, the more costly is trade, the lower are profits and the less likely we are to observe trade.

Consider two firms calculating the profitability of shipping goods to a distant location and facing prohibitive air shipping costs. The first firm is selling a good with low time sensitivity, and so can avoid air shipping costs by using ocean transport. The second firm is selling a good with high time sensitivity and so the profitability of air transport exceeds that of ocean transport. However both modes yield profits lower than the fixed costs of trade so that the firm chooses not to trade at all. In this case, time costs work by eliminating trade in the second good entirely. Further, they potentially bias our estimates of time sensitivity for the trade that actually occurs by censoring precisely those observations where time sensitivity is greatest. The solution in these cases is to use a Heckman two-step procedure, where the first step is to predict the probability that trade occurs, and then to condition on this probability in the probit or share regressions second stage.

DATA

Trade data: Define a "trade flow" as an observation on trade taking place for a given exporter x importer x HS6 product x time. For example, Germany's export of HS 830110, "pad locks of base metal", to Argentina in 2005 is a trade flow. We observe trade flows for all exporters worldwide into 6 South American importers (Argentina, Brazil, Chile, Colombia, Ecuador, Peru) for every HS6 product in years 1995 and 2000-2005 inclusive[13]. For each trade flow we observe the value of a trade including insurance and freight (cif value), and excluding insurance and freight (fob value), weight measured in kilograms, and transportation charges for trade. Each of these variables is reported separately for each transportation mode (air and ocean vessel). Denote the importer destination as d, exporter as j, HS6 product as k, and time period as t.

From the base variables we calculate the following:

Shipment prices are obtained by dividing fob trade values by quantities $p^m_{djkt} = fob^m_{djkt} / q^m_{djkt}$

Unit freight charges are transportation costs divided by trade weight, $g^m_{djkt} = \dfrac{cif^m_{djkt} - fob^m_{djkt}}{q^m_{djkt}}$.

Ad valorem freight charges are computed as $f^m_{djkt} = 1 + \dfrac{g^m_{djkt}}{p^m_{djkt}}$.

[13] Data for Ecuador are available from 2000-2004 only.

In our probability specifications we only observe freight charges for the single transportation mode chosen, but the specification requires data on the difference between air and ocean freight charges. For example, if pad locks shipped from Germany to Argentina only use air transport, then we observed air transportation charges but not ocean transportation charges. In these cases it is necessary to estimate the transportation cost that would have been charged to the firm in the mode not chosen.

For each mode m specify the per unit freight rate as a function of the value of the commodity shipped, the distance between the exporter and import pair, the oil price and a set of importer effects to obtain

$$\ln\left(g^{m}_{djkt}\right) = \beta_0 + \beta_1 \ln\left(p^{m}_{djkt}\right) + \beta_2 \ln\left(dist_{dj}\right) + \beta_0\left(\text{Oil Price}_t\right) + \delta_d + u_{djkt} \tag{7}$$

We then estimate (7) for each mode of transport by pooled OLS within HS4 commodites. This approach epxloits variation across HS6 commodities, exporters and time periods to identify the coefficients. We collect the estimated coefficient for each HS4 product category and predict the missing per unit freight charges. To compute the ad valorem freight rates we assume that the fob price does not change across the two modes of transportation. This means we can directly substitute the observed fob prices for the unobserved fob prices.

Our exercises also use the worldwide trade data in two cases: estimating a selection model, and in aggregating the value of time costs over different categories of goods. We draw on COMTRADE data extracted using the WITS data tool at the World Bank to measure the value of bilateral trade flows for each exporter x importer x HS6 product. For each HS6 product, we aggregate these over importers to calculate the value of exports to the world as a whole for each exporter j, XV_{jkt} .

Time Data: We use two sources of information on time delays associated with trade. First, we use the World Bank's Trading Across Borders dataset to calculate transit times for trade, including time for inland transit plus moving commodities through customs and ports to obtain the total inland transit time by export country, PT_j . The DB data also provides information on the total export costs, XC_j . Both of these variables are used in the selection equations where we estimate the probability that trade occurs.

We employ ship schedule data taken from the Port2Port Evaluation tool at www.ComPairdata.com for the fourth quarter 2006. From these data we are able to calculate average shipping times between ports in a particular exporter "j" and import destination "d" in South America. There are two complications. First, a majority of j-d pairs have no direct shipping connection. In these cases we use the shipping schedule to calculate all possible indirect routings between j and d through some hub country. We then select the minimum shipping time possible over all routes. For example, a shipment leaving Lagos Nigeria destined for Rio de Janeiro Brazil has no direct routing, but could be routed indirectly through Rotterdam Netherlands or through Hampton Rhodes Virginia in the United States. If Rotterdam yields the most direct route (measured in total days spent in transit) we use the time in transit for Rotterdam. The second complication is that the trade data in many cases report which specific country was used as a transport hub. In these cases, we calculate the transit time using the hub route reported in the trade data.

ECONOMETRIC SPECIFICATIONS

We begin by rewriting equation (4) in terms of observable and unobservable components. Let $Air_{djkt} = 1$ if exporter j, shipped commodity k to destination d exclusively by air in year t. Similarly, let $Air_{djkt} = 0$ the observed shipments of that import-export relationship where exclusively by ocean vessel. Specify the probability of air shipment as

(8) $Air_{djkt} = (1-\sigma)\left(\ln f^{A}_{jktc} - \ln f^{O}_{jktc}\right) + \sigma\tau\left(days^{O}_{jc} - 1\right) + \varepsilon_{djkt}$, where $\varepsilon_{dhjkt} = \sigma \ln\left(\frac{\nu^{A}_{djkt}}{\nu^{O}_{djkt}}\right) + \mu_{djkt}$

The error term now contains unobserved quality shifters for this exporter-importer pair and product. The standard concern with this specification is that there are components of the error terms (here: quality) that may be correlated with the regressors. We assume that these can be decomposed into exporter- specific and importer-specific terms, $\nu^{m}_{dhjkt} = \upsilon^{m}_{j}\upsilon^{m}_{d}\nu_{dhjkt}$. These terms capture the possibility that high-income countries both export and import higher-quality (and higher-priced) goods within each category, consistent with the evidence in (cite). Substituting these terms back into the specification to account for unobserved quality variation we arrive at the estimation specification

(9) $$Air_{djkt} = (1-\sigma)\left(\ln f^{A}_{djkt} - \ln f^{O}_{djkt}\right) + \sigma\tau\left(days^{O}_{dj} - 1\right) + \upsilon_{j} + \gamma_{d} + \mu_{djkt}$$

Based on the theory, specification (9) identifies the parameters from variation that is generated by individual firms switching exclusively between air and ocean shipment as the relative transportation and transit times change across products and export countries. Consistent with this idea, we interpret any importer-exporter relationship within a given product k as an individual firm and therefore exploit variation at the importer-exporter level.

Next we rewrite equation (5) in terms of observable and unobservable components. A key difference to the previous specification is that the underlying theory allow for firm heterogeneity and therefore exporters producing similar goods choosing different transportation schemes.

(10) $$\ln\frac{p^{A}_{djkt}q^{A}_{djkt}}{p^{O}_{djkt}q^{O}_{djkt}} = (1-\sigma)\ln\left(\frac{p^{A}_{djkt}}{p^{O}_{djkt}}\right) - \sigma\ln\left(\frac{f^{A}_{djkt}}{f^{O}_{djkt}}\right) + \sigma\tau\cdot\left(days^{O}_{dj} - 1\right) + \varepsilon_{djkt}$$
$$\text{where } \varepsilon_{djkt} = \sigma\ln\left(\frac{\nu^{A}_{djkt}}{\nu^{O}_{djkt}}\right) + \mu_{djkt}$$

As in the probit specification, the error term contains unobserved quality shifters for this country and product. Again, we use importer and exporter fixed effects to account for unobserved quality variation and substitute these expressions back into (10) to obtain the estimation specification

$$\ln \frac{p_{djkt}^{A} q_{djkt}^{A}}{p_{djkt}^{O} q_{djkt}^{O}} = (1-\sigma)\ln\left(\frac{p_{djkt}^{A}}{p_{djkt}^{O}}\right) - \sigma \ln\left(\frac{f_{djkt}^{A}}{f_{djkt}^{O}}\right) + \sigma\tau \cdot \left(days_{dj}^{O} - 1\right) + \upsilon_j + \gamma_d + \mu_{djkt} \tag{11}$$

A significant problem with the estimating equations above is that they can only be used in cases where a trade flow actually occurs. As we have noted, a common feature of these data is that no trade is observed in many cases, an outcome our model predicts if high time costs lower profits from exporting below the fixed costs. In other words, we see trade only in cases where time costs are very low!

To solve this problem, we employ a Heckman selection approach. The first stage estimates the probability that a trade flow will occur. The second stage then estimates equations (10) and (11), conditioning on this probability. We estimate the probability that an exporter can successfully enter a potential destination market using : the exporter's total value of exports to the world by commodity and year, XV_{jkt}, the average ocean transit time, $days_{dj}$, the total export cost by exporter, XC_j, and the total inland trade processing time by exporter, PT_j. Let $s_{djkt} = 1$ if we observe a trade flow of commodity k between exporter j and destination d in year t and $s_{djkt} = 0$ otherwise.

$$P(s_{djkt} = 1 \mid X) = \Phi(\delta_0 + \delta_2 \ln(XV_{jkt}) + \delta_2 \ln(days_{dj}) + \delta_3 \ln(XC_j) + \delta_4 \ln(PT_j))$$

The Heckman procedure generates a variable known as the inverse Mill's ratio, which becomes an additional explanatory variable in our estimation.