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GLOBALIZATION AND FREIGHT TRANSPORT COSTS IN MARITIME SHIPPING AND AVIATION

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SUMMARY

This report provides evidence and analysis on how changing patterns of globalization affect transportation demand and transport costs. Section One, “How Goods Move” provides data from Europe, North and South America describing which transport modes are employed for international trade and how that has changed over time. Measured by weight, nearly all international trade with non-adjacent neighbors moves via ocean vessels. In contrast, the value share of trade moved by air cargo is large and grew steadily from 1965 through 2000. By 2000, more than half of US and Irish export value was airborne. After 2000, the air share of trade fell sharply worldwide.

A primary reason for these large shifts in modal shares is explained in Section Two, “Measures of Transportation Costs”. The initial rise in air shipping corresponds to a period in which the relative price of air cargo dropped by a factor of 10. Between 2000-2008, air cargo rates rose by a third. In addition to aggregate trends, Section Two describes country and product specific data on transport costs. Inland shipping represents from 30 to 60 percent of the total door to door shipping bill, depending on the country in question. Ad-valorem transport costs are comparable in size or larger than tariffs –transportation expenditures represent 85 percent of the total costs (tariffs plus transportation) faced by the US as an importer, and 31-63 percent of total costs faced by Latin American Importers. Transportation costs are considerably higher for poor countries, and vary tremendously across products and source countries. This implies that transportation costs play an especially large role in altering relative prices across exporters and determining bilateral variation in trade.

Section Three, “What Determines Shipping Costs” adduces evidence explaining variation in freight rates across countries, products, and over time. Technological advances in the form of jet engines for air cargo and containerization for ocean cargo are responsible for sharp reductions in the cost of these modes. However, these technological improvements can be swamped by significant changes in input costs. For example, high oil prices are largely responsible for rapid increases in ocean cargo costs in the 1970s as well as rapid increases in air cargo costs after 2000. Variation in rates across countries is driven primarily by differences in infrastructure quality and the strength of market power for shipping lines. Variation in rates across products is driven primarily by differences in their weight to value ratio.

Section Four “Trends in Globalization from a Freight Perspective” provides evidence on trends in globalization and how these trends affect freight demand. Included in this discussion is the growth in manufacturing, variation in the weight/value ratios for trade across countries and over time, time costs, the changing geography of trade, and the changing organization of production, including vertical specialization/fragmentation and the growing importance of testing markets and "small value" trade flows.

Section Five “Looking Forward” provides the author’s suppositions about future trends in globalization and transport demand in the short and long run. The key trends are these: rapid economic growth in China and India will continue, continuing the re-orientation of trade toward Asia and pushing up demand for and prices of oil. These oil price rises will continue to disadvantage air shipping as they have done since 2000. Enormous current account deficits in the US, which have facilitated export-led growth in Asia and led to major cargo imbalances, will narrow. Finally, firms and individuals will find alternative channels – trade in technology, foreign direct investment, immigration -- other than moving goods for realizing the gains from trade.

1. How Goods Move

1.A. Trade with Non-adjacent Partners

Three-quarters of world trade takes place between countries that do not share a land border. Nearly all of this trade moves via ocean and air modes. Bulk commodities like oil and petroleum products, iron ore, coal, and grains are shipped almost exclusively via ocean cargo. Bulk cargoes constitute the majority of international trade when measured in terms of weight, but are a much smaller and shrinking share of trade when measured in value terms.

Manufactured goods are the largest and most rapidly growing portion of world trade. To illustrate how they are transported, Table 1-1 (taken from Hummels 2007a, original source data reported in Table footnotes) reports worldwide data on ocean and air shipping of non-bulk traded goods. Air shipments represent less than 1 percent of total tons and ton-miles shipped, but are growing rapidly. Between 1975 and 2004, air tonnages grew at 7.4 percent per annum, much faster than both ocean tonnage and the value of world trade in manufactures in this period. The relative growth of air shipping is even more apparent in looking at ton-miles shipped, with 11.7 per annum growth rates going back to 1951.

Assessing changes in the weight of trade is important for transportation planning. Assessing changes in the value of trade is important for assessing the economic significance of various transportation modes and their role in trade. Because the heaviest goods travel via ocean, weight-based data on international trade significantly understate the economic importance of air shipping. The final columns of Table 1-1 report the value share of air shipments in US trade with non-adjacent partners. In the past 40 years, air shipments have grown to represent a third of U.S. imports and more than half of U.S. exports with countries outside North America.

Is the US anomalous? Countries in Latin America and Europe recently began reporting trade with transport mode detail. Table 1-2 (taken from Moreira et al 2008, original source data reported in table notes) provides import data by mode for 11 LAC countries and the US as a comparison. For LAC trade with all countries worldwide the modal split is similar to the US, but with somewhat lower reliance on air shipping and greater reliance on maritime transport (except for land locked Bolivia and Paraguay).

Tables 1-3 through 1-6 provide similar data for EU imports and exports from all countries other than the EU[1]. Table 1-3 reports on import values, including modal shares in 2007, growth in those shares from 2000-2007 and the percentage growth in imports via each mode. In 2007, airborne imports were 18.1 percent of the total, down from 25.1 percent in 2000. In contrast seaborne imports were 50.3 percent of the import value, up from 41.5 in 2000. Of course, this is a period of rising trade, so the value of imports entering via all modes rose in this period (see last panel of Table 1-3), however airborne imports rose only slightly while seaborne import values rose 75 percent. There is great variance across countries in their reliance on air-borne v. ocean-borne shipments. Of course landlocked countries heavily employ airborne shipments (presumably the residual seaborne values indicate that the shipment entered somewhere in Europe via the sea). Richer countries are also more likely to use airborne shipments.

Table 1-4 provides a similar breakout for export value. Exports are more likely to use air (25.1 percent in 2007; down from 31 percent in 2000). And the growth in exports is skewed much more to the use of rail and road, rather than sea as was the case with imports. Note that airborne exports are especially important for the UK and Ireland. This likely reflects commodity composition (e.g. the prevalence of electronics and pharmaceuticals in Irish exports).

Finally, Table 1-5 and 1-6 provide data on imports and exports weight by transport mode. Airborne trade is a tiny share of the weight of trade. For the EU as a whole, 70 percent of imports and exports move via maritime routes. However, this fraction varies dramatically across countries reflecting coastal access and the importance of trade with non-EU eastern European countries.

Note that in Table 1-1 we see the US air share of imports and exports rising steadily from 1965 until a peak in 2000 before falling in 2004. Subsequent data for the US are not available, but EU data from 2000-2007 are available. Figure 1-1 plots the air share of EU trade from 2000-2007, both imports and exports. For both imports and exports the air share of trade has fallen rapidly since 2000.

1.B. Trade with Neighbors

Roughly 23 percent of world trade by value occurs between countries that share a land border. This number has been nearly constant over recent decades, though it varies significantly across continents. For Africa, the Middle East and Asia, between 1 and 5 percent of trade by value is with land-neighboring countries; for Latin America trade with land neighbors is 10 to 20 percent of the whole, and for Europe and North American it is 25-35 percent of trade.

Detailed data on the value of trade with neighbors is somewhat sparse. Unlike the case with air and ocean shipping there is no globally comprehensive sources of information on modal use but data from the US, EU and LAC data provide some insights. The US Transborder Surface Freight Data show that in 2007 imports by weight from NAFTA countries are 39% ocean, 21% truck, 20% rail, and 20% pipeline. Imports by value were 11% ocean, 55% truck, 18% rail, 10% pipeline, and 6% other.

The EU and LAC data are useful for seeing the importance of various land modes not just for immediately adjacent partners but with all continental partners. The second panel of Table 1-2 shows LAC imports from other LAC countries. Air use is lower and land use is much higher than in the US data. Table 1-7 shows the land modal shares of trade by weight for EU countries in 2006 and the change since 2000. Unlike the customs data shown in Tables 1-3 to 1-6, these data include trade within Europe. For most countries, the use of road dominates.

1. These data were downloaded from the Eurostats dataweb, "External Trade" theme. Apparently the only data tracking modal use comes from customs data, and EU-origin trade is no longer tracked through customs.

1.C. Changes in Modal Demand: Initial Lessons

Why did air transport grow so rapidly until 2000 and fall thereafter? As the next sections show, a major factor has been the relative cost of air shipping, which fell steadily until 2000, then rose sharply after that. But an equally important factor has been changes in the nature of trade.

To understand this point, recognize that demand for international transport is an indirect or derived demand that primarily depends on the demand for international trade itself. An important implication for transportation planning is that final consumers are sensitive to changes in the delivered price of products, not to changes in the transportation price. If the cost of transportation substantially affects the delivered price then modal choice will be driven by cost considerations. But if the transportation price is but a small fraction of the delivered price, it will likely be trumped by other factors such as timeliness or reliability.

For example, the gains from employing air shipping are more pronounced on longer routes. Choosing air transport from the UK to France might save a shipper 5 hours, while choosing air transport from China to France might save 5 weeks. An air premium may be worth paying to save 5 weeks, but not 5 hours. This is undoubtedly why air shipping is used far less extensively for intra-continental trade than for trade at a longer distance. It should be noted that the same lesson is true of all cost differentials related to transportation Port A may charge handling fees per container that are twice the handling fees for Port B, but unless these differences substantially impact delivered prices of products they will have minimal impacts on the derived demand for transportation.

Less obviously, but perhaps as important, Table 1-1 shows that a dollar of merchandise trade goods weighs much less today than in previous years. From 1960-2004, the real value of trade in manufactures grew about 1.5 percent per year faster than the weight of non-bulk cargoes. If bulk commodities are included in the calculation, the real value of all trade grew 1.8 percent faster per year than the weight of all trade.

Reductions in weight/value make it easier to shift from ocean to air shipping because it reduces the ad-valorem price differential between the two modes. Consider this example. I want to import a $16 bottle of wine from France. Air shipping costs of $8 are twice ocean shipping costs of $4. Going from ocean to air increases the delivered cost by $4 or 25 percent. Now suppose my tastes improve and I want to import a $160 bottle of wine from France so that the weight/value ratio of the product has dropped sharply. The shipping costs are the same, but now the $4 cost to upgrade to air shipping represents just a 2.5 percent increase in the delivered price. The consumer is much more likely to use the more expensive shipping option when the effect on delivered price is smaller.

I will revisit these issues in Section 4 as part of a broader discussion of changes in the nature of world trade and how these changes affect transportation demand.

2. Measures of Transportation Costs

This section of the paper reports price indices for ocean and air shipping along with ad-valorem measures of transportation costs. It draws heavily on data and discussion from Hummels (2007a). In some cases the data series in questions offers world-wide coverage of costs, while in others the data are drawn from sources with narrower geographic coverage. This makes it difficult to ascertain whether data patterns are unique to the particular source in question. Where appropriate I have commented on the generality of specific results.

2.A. Ad Valorem Measures of Transportation Costs

International trade economists typically express transportation costs in ad valorem terms, that is, the cost of shipping relative to the value of the good. This is useful because it describes the size of the wedge that transportation costs drive between origin and destination prices, and because it facilitates comparison with tariff barriers. The best data for evaluating the ad valorem impact of transportation costs over time comes from a few importers such as New Zealand, the United States, and the ALADI countries of Latin America that collect freight expenditures as part of their import customs declarations.[2]

2. An alternative approach constructs indirect measures of transportation costs using a "matched partner" technique. In principle, exporting countries report trade flows exclusive of freight and insurance and importing countries report flows inclusive of freight and insurance. If measured without error, comparing the valuation of the same flow reported by both the importer and exporter yields a difference equal to transport costs. Examples of papers using this technique include Geraci and Prewo (1977), Rose (1991), Harrigan (1993), Baier and Bergstrand (2001) and Limao and Venables (2001). Even UNCTAD's Review of Maritime Transport, the pre-eminent annual publication on international transportation and trade issues, relies heavily on matched-partner data from the IMF to construct measures of ad-valorem shipping costs on a worldwide basis. However, Hummels and Lugovskyy (2006) show that the "matched partner" technique is subject to enormous measurement error and in fact produces time series variation that is orthogonal to actual variation in shipping costs.

BOX 1

Denoting the origin price of a good as p, destination price as $p*$, and per unit shipping costs as f, we have $p* = p + f$. International trade economists typically express costs in ad-valorem terms, that is, the percentage change in prices induced by transportation,

$$\frac{p*}{p} = 1 + \frac{f}{p}$$

A common but inaccurate approach is to model the *f* term as a constant percentage τ of value shipped, in which case the ad-valorem cost is independent of the goods price, or $\frac{p*}{p} = p(1+\tau)$

These data enable us to examine ad valorem transportation costs for an individual good sold by a particular exporter, or to calculate aggregate expenditures on transportation divided by aggregate import value. This aggregate measure is equivalent to an average of ad-valorem transport costs for each good, after weighting each good by its share of value in trade. That is, define ad-valorem transport costs for an individual good as

$$\tau^k = \frac{f^k}{p^k}$$

We can then calculate the aggregate ad-valorem transport costs as the aggregate expenditures on transportation divided by aggregate import value. This is mathematically equivalent to a trade-weighted average of the transportability for individual goods k , $\tau^{agg} = \sum_k \tau^k s^k$, where s^k is the value share of good k in trade.

Figure 2-1 reports time series variation in total freight expenditures as a share of total import value for New Zealand and the US (omitting North America).[3] The New Zealand data cover 1963-1997, a period in which aggregate transportation expenditures fluctuated between a low of 7 percent of import value (in 1970) and a high of 11 percent (in 1974) but exhibited no clear trend. The U.S. data cover 1974-2004, a period in which aggregate expenditures on freight declined steadily from about 8 percent of the value of total imports in 1974 down to about 4 percent in 1997 before leveling off. However, the apparent downward trend in the US series may be misleading. The contrast with the New Zealand data and evidence in the next section makes clear that much of the apparent decline in aggregate US transport expenditures in this period is an artifact of the 1974 starting point and the large effect of the oil shock on prices in that year.

While Figure 2-1 accurately measures freight expenditures, this is not necessarily an accurate picture of transportation costs. Since the share of trade in a particular product is low when shipping costs are high, actual freight expenditures will tend to understate transportation costs faced by typical goods. In US data, for example, unweighted averages of transportation costs in a particular year are typically 2 to 3 times higher than the weighted average reported in Figure 2-1. Over time, a switch toward more proximate trading partners, or toward more transportable goods, can lower the aggregate value of expenditures on transportation even if true shipping costs are unchanged. Similarly, an increase in transport service quality

3. Canada and Mexico are omitted because freight expenditures on surface shipping are measured with much greater error.

such as a switch from ocean to air shipping can raise aggregate expenditures considerably. In the sections below, I provide measures that control for these important compositional shifts.

To get a broader perspective on the ad-valorem importance of transport costs, I next compare data from the US and Latin America. Table 2-1 is taken from Hummels, Lugovskyy, and Skiba (2008). It provides data on transportation costs for imports into the US and a number of Latin American countries in 2004, and makes clear several basic facts about costs of trade. One, ad valorem transport costs are negatively correlated with per capita income – they are 1.5-2.5 times higher for Latin American importers than for the United States, and systematically higher for low income exporters into a given import market.

Two, transport costs are comparable in size to, or larger than, tariffs. For the median good in US imports transportation represents 85 percent of the total costs (transport plus tariffs) faced by an exporter. For historical contrast, transport expenditures on the median good were half as much as tariff duties for US imports in 1958 (Waters, 1970), and equal to tariff duties in 1965 (Finger and Yeats, 1976). For Latin American importers, transportation costs represent from 31 to 63 percent of total costs faced by exporters in the median good. This is not because transportation costs are lower in LAC, as the first panel in the table makes clear. Rather, tariffs in LAC are higher as well.

Three, despite the fact that international transportation technology and the use of containerized liner shipping is common across goods and exporters, transportation costs vary enormously. This implies that transportation costs play an especially large role in altering relative prices across exporters and determining bilateral variation in trade. A useful summary statistic of variability is the coefficient of variation, calculated as the variance over observations divided by the mean. For the US and LAC data, we observe shipping costs for each product k and exporter j, so the coefficient of variation over j,k is

$$COV = \frac{VAR_{j,k}(\tau_{j,k})}{mean(\tau_{j,k})}.$$

For US imports, the coefficient of variation (across exporters and goods) in ad-valorem transportation costs is 1.4, meaning that shipments with costs that are one-standard deviation above the mean have costs 140 percent greater than the mean.

Even if we hold constant the product in question there is tremendous variation in transport costs across exporters to a given market. This pattern can be seen by calculating ad-valorem transportation costs for each product in US imports 2004 and sorting exporters from most to least expensive. For a typical product the exporter one standard deviation above the mean pays shipping prices 89 percent higher than the mean. Exporters in the 90^{th} percentile of costs faced shipping charges that were 11 times greater than those faced by exporters in the 10^{th} percentile. This is considerably more bilateral variation than is found in tariff rates. Variability in Latin America is comparable to or higher than the US. Given their size and variability, transportation costs are likely to play an especially important role in changing relative prices – lowering trade volumes in the aggregate and altering patterns of trade across goods and partners.

What explains this variation? In section 3 below, I provide detailed evidence and discussion on specific determinants of shipping costs that help to explain why they vary so dramatically across countries and products. Hummels, Lugovskyy, and Skiba (2008) provide a systematic analysis that decomposes variation in shipping costs into component influences: product characteristics and market characteristics including market power. For example, non-OECD exporters face shipping costs that are 38 percent higher than OECD exporters when shipping either to the US or to LAC countries. Differences in product prices explain 62% of this effect, (ad-valorem costs of shipping are lower for higher priced products), 7% is due to more intensive competition (more shippers on OECD routes), and only 6% is due to longer distances traveled. The remainder is not attributable to any specific causes, simply showing up as higher costs for non-OECD exporters after all measurable effects are accounted for. Similarly, LAC countries pay 27 percent higher shipping costs on their imports than does the US. Higher product prices on US routes explain 23% of this difference, more intensive competition on US routes explain 29%, shorter distances explain 12%, and higher tariffs on LAC routes (which enable shipping firms to charge higher markups) explain 44%.

2.B. Price Indices for Air Transport

Data on international air transportation prices are sparsely reported. However, the limited data do paint a clear portrait of decline over time in air shipping prices.

The International Air Transportation Association surveys international air carriers and reports worldwide data on revenues and quantities shipped in their annual *World Air Transport Statistics (WATS).* Figure 2-2 (taken from Hummels 2007a) shows average revenue per ton-km shipped for all air traffic worldwide, indexed to 100 in 2000. Over this 50-year period, this measure of costs per ton fell more than 10-fold. Expressed in 2000 U.S. dollars, the price fell from $3.87 per ton-km in 1955 to under $0.30 from 1955-2004.

The period from 1970 onward is of particular interest, as it corresponds to an era when air transport grew to become a significant portion of world trade, as shown in Table 1-1. In this period, more detailed data are available.

The International Civil Aviation Organization (ICAO) published a "Survey of International Air Transport Fares and Rates" annually between 1973 and 1993. These surveys contain rich overviews of air cargo freight rates (price per kilogram) for thousands of city-pairs in air travel markets around the world. The *Survey* does not report the underlying data, but it provides information on mean fares and distance traveled for many regions as well as simple regression evidence to characterize the fare structure. Using this data I construct predicted cargo rates ($ per kg shipped) in each year for world-wide air cargo and for various geographic route groups. I deflate this series in two ways: first I use the US GDP deflator to provide the price of air shipping measured in real US dollars per kg; second I deflate using the average price ($ per kg) for air shipped goods in US trade in this period. This second deflator then provides a rough measure of the ad-valorem incidence of air cargo for each year and route group.

Results are displayed in Table 2-2 (taken from Hummels 2007a). Pooling data from all routes, prices increase 2.87 percent annually from 1973 to 1980, and then decline 2.52 percent annually from 1980 to 1993. The increases in the first period largely reflect oil price increases. The timing of the rate reduction also coincides well with the *WATS* data, which show little price change in the 1970s and more rapid declines in the 1980s. The post-1980 price declines vary substantially over routes, with longer routes and those involving North America showing the largest drops.

More recent air cargo price indices are only available for the US. Figure 2-3 show air freight price indices constructed by the US Bureau of Labor Statistics for cargoes inbound to and outbound from the United States from 1991-2008. I deflate the BLS series using the U.S. GDP deflator to provide the price of air shipping measured in real US dollars per kilogram, and normalize the series to equal 100 in 2000. Note that the figures include both the aggregate series, and a sub-series for flights to/from Asia. (Further geographic aggregation has been made available only in the last two years.). The real price of outbound air freight fell substantially from 1992-2003 before turning up sharply. By the end of the period sampled here (second quarter 2008), rates had returned to a level not seen since 1993. Similarly, the real price of inbound air freight fell substantially from 1990-2001, and then rose significantly thereafter. These increases likely reflect a combination of greater security costs post 9-11 and higher oil prices. More on this below.

The sharp decrease and then increase in air cargo costs undoubtedly explain much of the modal change described in Section 1. Recall that the US imports data, which span the period of decrease then increase, exhibit air cargo usage moving inversely with prices – rising until 2000 and falling thereafter. The EU data begin in 2000 and exhibit a sharp decline in air usage in this period.

2.C. Costs of Ocean Transport

There are many price indices for tramp and liner shipping, but two reported in Figures 2-4 and 2-5 (taken from Hummels 2007a) stand out for their length of coverage. Figure 2-4 uses an index on tramp trip charters originally constructed by the *Norwegian Shipping News (NSN)* and later continued by *Lloyds Shipping Economist*. A trip charter is a contract to ship a large quantity of a dry bulk commodity between specific ports, and may include some minimal loading and/or unloading expenses. The trip charter price index represents a weighted bundle of spot market prices, measured in U.S. dollars per ton, for shipping major bulk commodities on several important routes world-wide. To evaluate the real costs of shipping over time I deflate these indices using both the U.S. GDP deflator, and also using a price index for bulk commodities typically shipped via tramps. Using the U.S. GDP deflator provides a constant dollar value for the unit price of tramp shipping a given quantity of merchandise. Using the bulk commodity price index yields the price of shipping a bundle of goods relative to the price of that bundle, a crude measure of the ad valorem barrier posed by shipping.

Figure 2-4 displays the price series for trip charters and shows several price spikes. The price spikes in the 1970s are clearly attributable to oil price shocks, and the price spike in the 1954-1957 period is probably due to a combination of high demand from unexpectedly large U.S. grain exports to Europe and the Suez Canal Crisis. Setting aside these spikes we can see two clear trends. The price of bulk shipping measured in real dollars per ton has declined steadily over time so that it is now half as much as in 1960 and a third the price in 1952. However, when measured relative to the commodity price deflator there are large fluctuations but no downward trend. While the cost of shipping a ton of wheat or iron ore has steadily declined, the cost of shipping a dollar value of wheat or iron ore has not.

Figure 2-5 reports the real price of liner shipping. It uses an index constructed by the German Ministry of Transport that emphasizes general cargoes, including containerized shipping and manufactured merchandise of all sorts. It also covers loading and unloading expenses, particularly relevant since reductions in cargo handling costs are thought to be a major source of gains from containerization. This index does not offer comprehensive geographic coverage, focusing only on those liners loading and unloading in Germany and Netherlands. As with the tramp index, I deflate the index to get the real price of shipping, using both the German GDP deflator, and a composite traded goods price index for Germany. Measured relative to traded goods prices, liner prices rise steadily against German import prices before peaking in 1985. Measured relative to the German GDP deflator liner prices decline until the early 1970s, rise sharply in 1974 and throughout the late 1970s, spike in the 1983-1985 period (likely due to the rapid real depreciation of the DM which made German purchases of all international goods and services more expensive), then decline rapidly thereafter.

The rapid increases in liner prices facing Germany in the 1970s were wide-spread. Throughout the 1970s, UNCTAD's annual *Review of Maritime Transport* reported price changes announced by shipping conferences, with annual nominal increases of 10-15 percent being common across nearly all routes. The *RMT* also reports the ad valorem shipping rates for a small number of specific commodities and routes from 1963-2004: examples include rubber shipped from Malaysia to Europe, cocoa beans shipped from either Ghana or Brazil to Europe, and tea shipped from Sri Lanka to Europe. Converted to real dollars per quantity shipped, these liner prices increased by 67 percent in the 1970s.

2.D. Constructing Price Indices from Regression Evidence.

Index numbers attempt to measure changes in the price of a non-changing bundle of services. The difficulty with using these numbers is that they frequently lack comprehensive coverage, and users do not have the option to inspect or re-construct the bundles of goods included in the index. Further, attempts to construct ad-valorem equivalents of the index numbers will be crude at best. One solution to this problem is to use a regression approach to control for compositional change, thereby creating a kind of pseudo-price index.

Hummels (2007a) shows how to use detailed data on shipping costs taken from customs data along with a regression approach to control for changes in the composition of trade. The data on shipping costs are taken from the U.S. Imports of Merchandise data for 1974-2004. These data provide extremely detailed shipment characteristics including transport mode, weight, value, freight and insurance charges, and duties for each exporter with commodities disaggregated to the five-digit SITC level. The regression relates the ad valorem air freight cost in logs for commodity k, shipped from exporter j, at time t. The independent variables include a separate intercept for each exporter-commodity shipped, the weight/value ratio in logs for each shipment, and year dummy variables. The exporter-commodity intercepts control for the fact that iron-ore from Brazil has higher transportation costs in every period than shoes from Taiwan, and the weight/value ratio controls for compositional change over time within an exporter-commodity such as Taiwan shipping higher quality shoes.

The dashed line in Figure 2-6 (taken from Hummels 2007a) reports an unadjusted measure of ad valorem air shipping costs: that is, aggregate expenditures on air shipping divided by the value of airborne imports. (This is very similar to Figure 2-1, except that only air shipping data are employed.) This line trends down slowly, dropping only 2 percentage points over 30 years. As discussed earlier, measures of aggregate transportation expenditures calculated in this way do not take into account changes in the mix of trade partners or products traded. The solid line in Figure 2-6 reports the fitted trend in air shipping costs and is equivalent to ad valorem transportation expenditures after controlling for compositional change. Once changes in the trade partner and product mix have been taken into account, the fitted ad valorem cost exhibits a greater absolute decline in air transportation costs.

Figure 2-7 (taken from Hummels 2007a) provides a parallel picture for ocean shipping. Again, the dashed line shows aggregate expenditures on ocean shipping divided by total value of ocean shipping in each year. It shows an initially rapid decline in transportation expenditures, followed by a 25 year period in which rates fluctuate but do not otherwise decline. The solid line represents ad valorem ocean shipping costs after controlling for exporter-commodity composition and changing weight/value ratios. The fitted rates decline initially, then increase through the mid-1980s, then decline for the subsequent 20 years.

Moreira et al (2008) used a similar approach to calculate pseudo price indices for ad-valorem ocean and air shipping costs for Latin American imports. These results are reported in Figure 2-8 for air cargo and Figure 2-9 for ocean cargo. Note that their data for LAC includes years 1995 and 2000-2005 (so the 1995-2000 trend is interpolated). The air cargo series shows, on average, a decline from 1995 to 2000 though the magnitude varies from roughly constant (for Chile) to steep declines in air cargo prices for Argentina. After 2000-2001 air cargo prices turn up sharply. In contrast, ocean cargo expenses decline from 1995-2003 (with a blip up in 2001) before increasing from 2003-2005.

2.E. Door-to-door costs: inter-modal cost data

One difficulty with assessing international transportation costs is that most available data sources offer coverage that begins at the exit port and ends at the entry port. The result is the omission of a crucial component of costs: getting goods to and from the ports. This inland component is plausibly a very large fraction of the overall bill.

Two large data exercises provide some cross-country perspective on the magnitudes of these inland costs. The World Bank Doing Business database provides data on costs of inland movements, broken out into various components: inland transport, ports, and other (customs, and assembly). Figure 2-3 provides an aggregation of these costs for each broad region (with country data weighted by populations to construct regional averages). Costs are much lower for East Asia than for other regions, and highest for Sub-Saharan Africa. The distribution of these costs also varies considerably across regions; inland costs being very low for East Asia and much higher elsewhere.

De (2008) systematically extracted shipping cost quotes from the Maersk-Sealand shipping cost database for many city pairs within Asia. This allowed him to assess the relative importance of the inland relative to the ocean segment for each city-pair, which can then be aggregated into country pairs, or aggregated into shipping costs for a country as a whole. An extract of this data is shown in Figure 2-4, which reports the average inland and ocean shipping costs for seven major Asian exporters. The total freight bill varied widely from $1284 per TEU for Malaysia up to $3488 for India. The inland share of freight also varied widely, with China at the low end (28%) and Thailand at the high end (60%). Also noteworthy: the expensive of moving a container through Indian's interior is equal to the expense of the entire trip for Thailand.

3. What determines shipping costs?

Section 2 makes clear that transportation costs vary substantially across products, across countries, and over time. In this section, I discuss evidence on the determinants of shipping costs to help explain this variation. I begin with air cargo, and discuss the role of technology, policy, shipment characteristics, and cost shocks. I proceed next to a discussion of the changes in ocean cargo, including changes in technology and institutions, input costs, port infrastructure, scale effects, and market power.

3.A. Air Cargo

3.A.1. Technological and Institutional Change

Commercial aviation has undergone rapid technological change, including improvements in avionics, wing design, materials, and most importantly the adoption of jet engines. Compared to the piston engines they replaced, jet engines are faster, more fuel efficient and reliable, and require much less maintenance. Gordon (1990) calculates price indices for aircraft that adjust for these quality changes and finds dramatic declines in real prices after jet engines were introduced. From 1957-1972, the period in which jet engine usage became widespread, quality-adjusted real prices fell at a rate of 12.8 to 16.6 percent per year, depending on the method of calculation. Quality change in commercial aviation slowed considerably after 1972, but quality-adjusted aircraft prices were still dropping by 2.2 to 3.8 percent per year from 1972-1983.

The timing of these changes are closely reflected in the WATS data reported in Figure 2-2. As with Gordon’s measure of quality-adjusted aircraft prices, declines in air transport prices are especially rapid early in the period. Average revenue per ton-km declined 8.1 percent per year from 1955-1972, and 3.5 percent per year from 1972-2003.

More recently there have been are two significant shocks to institutions that affect both air travel and air cargo. The first, as documented in Micco and Serebrisky (2006) is the signing of agreements to liberalize trade in air services. They discuss a series of 50 "Open Skies Agreements" by the US beginning in 1992. These agreements, which apply to passenger, cargo, and combination air transport include several key provisions, including: free competition (no restrictions on number of airlines, their capacity or service frequency); pricing determined by market forces (as opposed to government imposed fares); and fair and equal opportunity to compete (freedom of airlines to establish sales offices and ground handling services). Micco and Serebrisky (2006) use data on air cargo expenses for the US to estimate that signing OSA's reduce air transport costs by 9%.

Finally, tighter security associated with the 9-11 terrorist attacks may have increased costs both for air cargo and for air passengers, though most of the relevant evidence focuses on reduced quantities rather than direct information on costs. For example, Blalock et al (2007) estimate that tighter screening procedures introduced after 9-11 reduced passenger volumes by 6-9 percent. That said, it is possible to get at some of the higher air transport costs associated with 9-11. The Air Transport Association publishes cost indices for the air industry, breaking out detailed cost factors such as fuel, labor, maintenance, communications, and insurance. Insurance is especially interesting. Between 2001Q3 and 2002Q1, the cost of insuring the aircraft itself tripled. In that same period, non-aircraft insurance for the airlines (i.e. insuring everything other than the aircraft itself) rose five-fold. In both cases, insurance costs have subsequently dropped, but remain roughly double what they were before the attacks.

Figure 3-1 shows a time series graph for air passenger fares taken from Cristea (2008), with these last two events superimposed. The signing of open skies agreements correlate to sharp reductions in air prices, a trend that continues until the fourth quarter of 2001.

3.A.2. Regression Evidence: Distance, Oil Prices.

Hummels (2007a) examines air cargo prices from US imports data, relating the cost of shipping good k from exporter j to various determinants. Ad-valorem air transportation costs are increasing in the weight/value ratio of the good, the distance shipped, and jet fuel expenses. I will return to the importance of weight/value below, but first consider the role of distance. Interestingly, the effect of distance is steadily eroding over time. In 1974 the elasticity of air transportation costs with respect to distance was 0.43, but had dropped to 0.16 by 2004. To better understand the impact of this change, we can calculate the air shipping price paid by an exporter 14,000 kilometers from the US compared to an exporter 2,000 kilometers away. The distant exporter would have paid air shipping prices that were 2.3 times that of the proximate exporter in 1974, but only 1.3 times that of the proximate exporter in 2004.

Fuel prices are an important determinant of costs. Several studies have examined the elasticity of aviation costs with respect to fuel prices (hereafter: fuel elasticity). Using the 1974-2004 time series and a Cobb-Douglas cost structure, Hummels (2007a) estimates that a fuel elasticity of 0.26. To the extent that the technology for passenger aviation and cargo aviation is similar, other studies focused on passenger aviation may be useful. Caves et al (1984) estimate translog cost functions for US passenger airlines from 1970-1981, and find a direct fuel elasticity ranging from .166 to .196.[4] Chua et al (2005) provide similar estimates on quarterly data from 1994-2001, and find a direct fuel elasticity ranging from .11 to .126. Oum and Yu (1998) examine worldwide passenger aviation from 1986-1993 and estimate a direct fuel elasticity of 153.

Thus we have cost estimates ranging from .11 to .26, depending on the functional forms employed, the time period, and whether the data sample uses cargo v. passenger aviation. These numbers imply that doubling oil prices, say from $50 to $100 a barrel, would result in aviation cost increases of 11 to 26 percent. However, these estimates significantly understate the cost increases experienced by passenger aviation in the last few years.

Figure 3-2 displays data on airline (passenger and mixed use passenger/cargo) operating costs taken from the Air Transport Association. It shows aggregate measures of operating costs (indexed to 100 in 2000), along with an index of fuel costs, and the share of fuel costs in overall operating expenses. Airline operating costs have risen 89 percent since 2000 and much of that increase can be ascribed to fuel cost increases. Recall that the BLS cargo price indices in Figure 2-3 rose sharply sometime after 2001. In the first quarter 2002, the fuel price index was at 79, the overall cost index was at 110, and fuel costs represented just 9.9% of operating costs. By first quarter 2008, the fuel cost index was at 358.7, the overall cost index had reached 229, and fuel represented 29.4% of airline operating expenses.

These numbers allow for a simple back of the envelope calculation of the fuel elasticity. Dividing the (log) percentage change in total costs by the (log) percentage change in fuel prices, we get a fuel elasticity of

4. Translog cost functions include interactions between each input cost and other inputs. To evaluate the total effect of an input cost shock on total fares it is necessary to evaluate the partial derivatives of the cost function at the means of the other variables. Unfortunately, the Caves et al, Chua et al, and Oum and Yu studies cited here do not report other variable means so only the direct effects can be calculated.

$$\ln\left(\frac{228}{110}\right)/\ln\left(\frac{358.7}{79.7}\right)=.48$$

That is, a doubling of fuel prices leads to a nearly 50 percent increase in aviation costs.

3.B. Ocean shipping

3.B.1. Technology and Institutional Change -- *Containerization and Open Registries*

Ocean shipping has undergone several important technological and institutional changes in the post-war era including the growth of open registry shipping and the introduction of containerization. Open registry shipping is the practice of registering ships under flags of convenience – for example, Liberia or Panama--to circumvent higher regulatory and manning costs imposed by wealthier nations. Open registry fleets comprised 5 percent of world shipping tonnage in 1950, 31.1 percent in 1980, and 48.5 percent in 2000. (OECD, *Maritime Transport*, for 1950; UNCTAD Review of Maritime Transport, various years). Tolofari (1989) estimates that vessel operating costs for open registry ships are from 12 to 27 percent lower than traditional registry fleets, with most of the estimated savings coming from manning expenses.

Containerized shipping is thought by many specialists to be one of the most important transportation revolutions in the twentieth century. (Levinson 2006) The use of standardized containers provides cost savings by allowing goods to be packed once and moved over long distances via a variety of transport modes--truck, rail, ocean liner, rail, then truck again--without being unpacked and repacked. This reduces direct port costs such as storage and stevedoring (port labor) as well as indirect costs incurred during lengthy port stops (the rental rate on unused capital while a ship sits idle in port). The indirect costs are critical: estimates place break-bulk (non-container) cargo ships' time in port at one-half to two-thirds of the ship's life (UNCTAD, Unitization of Cargo). Containerization also creates savings on the ocean leg. Larger and faster ships substantially reduce the price per ton-mile while the ship is steaming, but they incur higher indirect port costs (idle time) in proportion to their increased capital expense.(Gilman, 1983). Because containerships spend more time steaming, investments in larger, faster ships become feasible.

Containerized shipping was first introduced in the United States in the 1960s, then on U.S.-Europe and U.S.-Japan routes in the late 1960s and into the 1970s, then to developing countries from the late 1970s onward. The reason behind this seemingly slow pattern of diffusion lies in the large fixed costs of adoption, and the differential cost savings containers yield. To make full use of containerization requires container-ready ocean liners and ports adapted to container use, which requires specialized cranes, storage areas, and rail-heads. As a result, containerization was first adopted on the most heavily traded routes. Developing nations were especially slow to adopt, both because of lower scale and because of factor prices. In countries where capital is scarce and labor abundant, the capital cost of building container ports is higher, and the port labor cost savings of containers much lower.

How big are the cost savings from adopting containerization? Blonigen and Wilson (2006) use the US Waterborne Trade Database 1990-2004 to estimate that doubling the share of trade that is containerized lowers shipping costs by 5 percent. Hummels (2007) uses a longer time series (1974-2004) that spans the period in which adoption of containerization was underway and in which there is a much more pronounced "before and after" effect of adoption to measure. He finds that, for a given exporter and commodity, doubling the percentage of cargo that is containerized leads to a reduction in shipping costs of 13.4 percent.

3.B.2. Other Input Costs.

Figure 2-5 shows that ocean liner freight rates were rising sharply in the period shortly after the introduction of containerization to European liner trades. If containerization and the associated productivity gains led to lower shipping prices, as Levinson (2006) qualitatively documents, and Blonigen-Wilson (2006) and Hummels (2007a) estimate, why does the effect not show up in price indices capturing the cost of liner shipping?

In the period during which containerization was spreading, other input costs including fuel, ship prices, and port costs, were skyrocketing. An UNCTAD (1977) study, "Port Problems," revealed port cost increases in the 1970s ranging from 10 to 40 percent per annum, resulting in an overall increase in liner conference costs of as much as 7.5 percent per annum. Sletmo and Williams (1981) report that rising steel and labor costs resulted in sharply higher shipbuilding prices in the 70s and that liner operating costs rose 14-18 percent per annum in the 1970s as a result of the oil price shocks.

This historical experience is relevant because it suggests that congestion and fuel prices can swamp technological advances. Recall that Figures 2-6 and 2-7 show steady downward trends in US ocean and air shipping prices. However, part of this apparent decline may be due to the fact that the US data series starts in 1974 when oil prices – a critical transportation input – were unusually high. Using the historical data, Hummels (2007a) estimates an elasticity of ocean cargo costs with respect to fuel prices between .23 and .32. Ocean bunker fuel prices rose four-fold in real terms between 1973 and 1974. Combining this with the measured elasticity of 0.232 implies a 92 percent increase in ocean shipping costs in this year. That estimate matches very closely to estimates of fuel-related cost increases constructed from shipping fleet micro data (Sletmo and Williams, 1981). Taking the average fitted value of ocean shipping costs in 1974 from Figure 2-7 (9.9 percent ad-valorem) and using this implied cost shock gives 1973 ad-valorem ocean costs of 5.2 percent – a level comparable to rates in 2000.

As noted in the discussion of aviation costs, recent increases in oil prices resulted in substantial increases in the cost of cargo and passenger aviation. Were there similar increases for ocean shipping? Table 3-1 reports crude oil prices and liner rates ($ per TEU) for major liner routes at quarterly frequencies between 1998 and 2008. The liner data are collected and reported online by Containerisation International. Between 2002Q1 and 2004Q4, oil prices doubled. Freight rates also increased, by an average of 25 percent across all routes. This implies an elasticity of freight rates with respect oil prices of .25, quite similar to the estimate from Hummels (2007a). Between 2004Q4 and 2008Q1 oil prices doubled again, but liner rates only increased by 11 percent on average, for an implied elasticity of .11.

Note however that rates of change differ substantially across routes. For example, from 2002Q1 to 2004Q4 routes outbound from the US experienced declines in rates, while routes outbound from Asia and Europe experienced very large increases -- as much as 71 percent for cargos outbound from Asia to Europe. Two explanations for this variable response to large fuel price increases come to mind. First, the fuel intensity of liner service depends on the length of route. On short hauls time spent in port and port costs comprise a larger share of operating expenses, while on longer hauls such as Asia-Europe trade port charges are less important and fuel prices figure more prominently in overall costs. Second, capacity constraints may lead to lead to sharply rising prices when volumes increase, as well as unbalanced rates as a function of unbalanced trade. For example, Asia to the US rates are double the reverse, likely reflecting the large imbalance in trade volumes driven by US trade deficits. A consequence is that, while higher fuel cost do show up in higher rates, the correspondence is much weaker than is seen in aviation.

3.B.3. Scale Effects and Market Power

The rise in world trade may have had significant impacts on shipping prices through scale effects. In periods of rapidly rising demand, shipping capacity becomes scarce, ports become congested, and spot shipping prices rise quickly. This is readily apparent from inspection of Table 3-1. Imbalances in trade lead to large differences in rates on the same trade route, depending on the direction of the flow. Similarly, at the height of the US business cycle in 1999-2000 shipments from Asia ran as high as $2203 per TEU. These rates dropped nearly 50% by the low point of the US recession in 2001-2.

Over longer periods however, rising demand for shipping may actually lower shipping prices, especially in smaller countries with low trade volumes. To explain, the capacity of a modern ocean-going liner vessel is large relative to the quantities shipped by smaller exporting nations. As a consequence, vessels may stop in a dozen ports and in different countries to reach capacity. As trade quantities increase, it is possible to more effectively realize gains from several sources. First, a densely traded route allows for effective use of hub and spoke shipping economies – small container vessels move quantities into a hub where containers are aggregated into much larger and faster containerships for longer hauls. Second, larger trade volumes allow for the introduction of specialized vessels (reefers, ro-ros) and larger ships that enjoy substantial cost savings relative to older smaller models still in use. Third, larger trade volumes induce investment in port infrastructure, and better port infrastructure is highly correlated with lower shipping costs (Limao and Venables (2001), Clark et al (2004), Fink et al (2002), and Haveman et al 2008).

Hummels, Lugovskyy, and Skiba (2008) systematically examine the effect of market power in shipping, and their arguments and evidence are worth reviewing in depth. First, trade growth along a route promotes greater entry by shipping lines: In 2006 one in six importer-exporter pairs was served by a single liner service, and over half were served by three or fewer. Figure 3-3 (taken from Hummels et al 2008) displays the number of shipping lines on a trade route graphed against exporter GDP -- large countries enjoy more firms competing for their trade.

To show how market power works, Hummels et al (2008) model the shipping industry as a Cournot oligopoly and determine optimal shipping markups as a function of the number of carriers and the elasticity of transportation demand faced by carriers. A key insight of the model is that transportation is not consumed directly; instead carriers face transportation demand derived indirectly from import demand. This implies that the impact of an increased shipping markup on the demand for transportation depends on the share of transportation costs in the delivered price of the good, and elasticity of import demand.

To make plain the intuition behind the model, suppose the marginal cost of shipping either of two goods equals $10, and carriers are considering adding a $5 markup. The first good has a factory price of $10, so the markup will increase the delivered price by 25%. The second good has a factory price of $90, so the markup increases the delivered price by 5%. The same shipping markup has a much larger effect on the delivered price of the $10 good because shipping costs represent a larger share of the delivered price. Further, when considering the impact of shipping prices on the delivered price of goods, it is necessary to examine product prices inclusive of tariffs. Raising the tariff on a good raises its price inclusive of the tariff, lowers the percentage impact of a given transportation charge on the delivered price, and therefore increases the optimal shipping markup. This suggests a particularly deleterious role for tariffs in limiting trade. Tariffs raise foreign goods prices directly by taxing them, and indirectly by inducing higher shipping prices, and both reduce trade flows.

A second key point of the Hummels et al model relates to the responsiveness of trade to increased prices. Returning to our example above, now suppose we have two traded goods with a factory gate price of $90 and marginal costs of shipping equal to $10, so that a markup of $5 will yield an equal 5% increase in the delivered price of each good. The first good is a differentiated product and faces an import demand elasticity equal to 1.1. Here, a markup that yields a 5% increase in delivered price reduces traded quantities, and therefore demand for transportation services, by only 5.5%. The second good is a highly substitutable commodity and faces an import demand elasticity of 10. Here, the markup raises prices by 5% but lowers quantities traded and demand for transportation services by 50%! In the latter case the identical markup reduces import (and therefore transportation) demand to a much greater degree, limiting the carrier's optimal markup.

Hummels et al (2008) show that the market power of shipping firms is extremely high when they are moving goods with inelastic import demand, and when marginal costs of comprise a small fraction of the overall delivered price. In these cases, it is easy to generate examples where optimal markups could be an order of magnitude higher than the marginal cost of shipping. However, entry by rival liner companies can very quickly erode this pricing power. Using typical values for shipping costs and import demand elasticities, a monopoly shipper would charge a markup 6 times marginal costs of shipping, while entry by a single rival would cut this markup in half. Hummels et al (2008) provide strong empirical evidence for the theoretical claims: shipping prices are higher when (a) goods prices are high; (b) tariffs are high; (c) import demand elasticities are low; and (d) the number of rival firms are low. They claim that these effects generate the majority of variation in transport prices observed in the data.

4. Trends in Globalization from a Freight Perspective

In the preceding sections we document significant changes in modal usage and in freight costs. To a large extent freight costs move in response to changes in technology and shocks to input costs (oil, shipbuilding, port congestion). But freight costs are also affected by what is being traded, and that has changed over time. Similarly, modal usage responds to changes in relative prices – when air shipping falls in price more firms employ air cargo. But the benefit derived from air shipping depends on what is traded, and that has changed over time. In this section I discuss trends in globalization and how they affect freight demand. I focus on changes in the commodity composition of trade, changes in the organization of production, and changes in the partner composition of trade.

4.A. The Changing Commodity Composition of Trade

4.A.1. Growth in Manufacturing.

Table 1-1 shows that from 1955-2004 trade in manufactured goods grew 27-fold in real terms from $222 bn to $6022bn, roughly four times faster than all other trade. The shift from trade in agricultural and extractive goods to trade in manufactured goods affects transportation demand in (at least) six ways. I briefly summarize them here, and develop many of these themes in greater depth in the following sections.

First, it raises the demand for air transport relative to other modes. This is because manufactured goods have, on average, a lower weight/value ratio than do commodities, and because they are more time sensitive. Second, manufactured goods are containerized to a much greater extent than bulk commodities, allowing the use of standardized vessels. Third, as just argued in the section on market power in shipping, transportation demand is a derived demand and depends on product characteristics, including weight/value and the import demand elasticity for goods. Both are lower for manufactures than for commodities resulting in, ceteris paribus, greater market power for shipping firms. Fourth, production of manufactures is much more footloose than is trade in commodities: countries can develop a comparative advantage in textile production, but they are either endowed with oil and iron ore, or they are not. This means that logistics capabilities become an important source of comparative advantage – firms can compete on delivery time and price. Fifth, and related, production of manufactures can be fragmented into stages and the ability to move goods (and people) in a timely and coordinated manner between stages is paramount. Sixth, manufactured goods proceed through life cycles of introduction and then slow maturation, which implies that demand for manufactures is initially uncertain and firms must experiment with potentially successful goods. This implies a life-cycle of transportation demand as well, with early stages requiring flexibility, and subject to low scale.

4.A.2. The weight to value ratio of trade

Transportation specialists are accustomed to thinking of transportation costs in per unit terms, the cost of transportation services necessary to move grain a ton-km or to move one TEU container from Los Angeles to Hong Kong. International trade specialists who pay attention to shipping costs as an impediment to trade are accustomed to thinking of these costs in ad-valorem terms, the cost of transportation services necessary to move a dollar of grain or microchips between two points. The distinction is important because even if the cost of moving one TEU container remains constant over time the ad-valorem cost and the implied impediment to trade will change as the contents of the container grow more valuable.

To see this, suppose we sell one kilogram of a good at a price per kg of p, and pay shipping costs f per kg shipped. Note that the price per kilogram, p, is just the value/weight ratio, that is, the inverse of the weight/value ratio. If the shipping price per kg f is independent of the goods price per kg, the ratio of destination to origin prices is

$$\frac{p^*}{p}=\frac{(p+f)q}{pq}=1+\frac{f}{p}=1+f\left(\frac{weight}{value}\right) \quad (0.1)$$

If the container holds scrap metal, p is low (weight/value is high), and the ratio p*/p is high. That is, shipping charges drive a large wedge between the prices at the origin and destination. If the container holds micro chips, p is very high (weight/value is very low), the ratio p*/p is close to 1, and shipping charges drive only a small wedge between prices at the origin and destination.

Of course, the shipping charge f may be increasing in the value of the container's content because higher value goods require more careful handling and a larger insurance premium. The shipping charge f may also be increasing because optimal markups are rising in p, as discussed in the market power section (3.b.3) above. We can then write the per kg shipping charge as $f = p^{\beta}X$, where X represents other costs shifters such as distance, port quality and so on. In this case we have

$$p^*/p=1+p^{1-\beta}X=1+X\left(\frac{weight}{value}\right)^{\beta-1} \quad (0.2)$$

Unless $\beta=1$ the weight/value ratio of a product will be an important determinant of the transportation expenses incurred when trading that product. Hummels and Skiba (2005) and Hummels, Lugovskyy and Skiba (2007) examine the dependence of shipping costs on product weight/value. They estimate that a 10 percent increase in product weight/value leads to a 4-6 percent increase in shipping costs measured ad-valorem, i.e. relative to the value of the good shipped. Further, since there is tremendous variation across products in weight/value ratios, weight/value explains far more variation in observed transportation costs than do other observables including: the distance goods are shipped, the technology with which they are shipped, the quality of port infrastructure, or the intensity of competition between carriers on a trade route.

To see how this calculation works, take Hummels' (2007a) estimate that the elasticity of air shipping costs with respect to weight/value is 0.492. By measuring goods prices in units of price/kilogram, we can use the coefficient on weight/value to calculate the freight charges faced by high- and low-priced goods. For example, a volume of shoes that is worth \$100 per kilogram will face much lower ad valorem costs of air shipping than shoes worth \$10 per kilogram:

$$f^{\$100}/f^{\$10}=\left(\frac{\$100/kg}{\$10/kg}\right)^{0.494-1}=.31$$

As Schott (2003) notes, the variance of U.S. import prices within a particular product category has grown over time. As the spread between high-priced and low-priced goods in each product category widens, the transportation cost advantage enjoyed by high-end goods is growing over time.

Figure 4-1 provide data on the weight/value ratio (kg/$ -- in constant year 2000$) for the imports and exports of several EU countries from 1988-2007. These data are calculated by collecting the weight /value ratio of each shipment, and aggregating. More specifically, denote the reporting country as i, their partner as j, the product shipped (CN 8) as k, and the year as t. Then the weight/value ratio of the shipment is

$$\varpi_{i,j,k,t} = \frac{(\text{weight in kg})_{i,j,k,t}}{(\text{value in 2000\$})_{i,j,k,t}}$$

We can then aggregate the weight/value ratio for a particular country and year by summing the weight over all shipments divided by the value over all shipments,

$$\varpi_{i,t} = \frac{\sum_{j,k}(\text{weight in kg})_{i,j,k,t}}{\sum_{j,k}(\text{value in 2000\$})_{i,j,k,t}}$$

which is equivalent to multiplying the weight/value ratio of each shipment by its share in trade for that country and time period, and summing.

$$\varpi_{i,t} = \sum_{j,k} \varpi_{ijkt} s_{jk}$$

Figure 4-1 shows no obvious trend over time in weight/value ratios for the included country. However it does reveal several interesting facts. First, with the exception of Greece and France, imports are heavier than exports, a likely indication that trade costs on imports exceed those on exports. Second, the weight of exports is especially low for Ireland and for the UK, which explains why these countries rely on air shipping of exports to a far greater extent than do other EU countries.(see Table 1-4).

Figure 4-2 calculates aggregate weight/value ratios similarly, except that it aggregates over all EU countries but disaggregates by continental partner. This shows how EU trade with Asia and North America differs from trade with Latin America and Africa. Trade with Asia and North America, both imports and exports, is extremely light. Imports from all other sources are much heavier, reflecting the importance of bulk commodities in trade with the continents.

Contrast this with data calculated for Asian trade in Hummels (2008). Figure 4-3 reports time series on weight/value measured in kg per constant year (2000) US dollars for each Asian country's imports (solid line) and exports (dashed line) in Figure 1. Several patterns are notable. One, a dollar of exports weighs far less for the developed market economies (Japan, Korea, Taiwan, Hong Kong, Singapore) than for the emerging market economies. Indonesia is a notable outlier in the weight of its exports, which are almost 40 times heavier per dollar than those of Singapore or Japan. Two, most of these Asian economies (with the exception of Malaysia and Indonesia) are net importers of weight, that is, their import bundles weigh far more than do their export bundles. Three, China's imports are getting heavier and exports are getting lighter as China imports raw materials, transforms them, and shifts increasingly to high value exports.

In addition to affecting the ad-valorem transportation charge, reductions in weight/value make it easier to shift from ocean to air shipping because it reduces the ad-valorem price differential between the two modes. Consider this example. I want to import a $16 bottle of wine from France. Air shipping costs of $8 are twice ocean shipping costs of $4. Going from ocean to air increases the delivered cost by $4 or 25 percent. Now suppose my tastes improve and I want to import a $160 bottle of wine from France so that the weight/value ratio of the product has dropped sharply. The shipping costs are the same, but now the $4 cost to upgrade to air shipping represents just a 2.5 percent increase in the delivered price. The consumer is much more likely to use the more expensive shipping option when the effect on delivered price is smaller.

If we arrange goods along a continuum from heaviest to lightest, goods at the heaviest part of the continuum tend to be ocean shipped, and those at the lightest part tend to be air shipped. This pattern can be seen in the level of the ad valorem freight expenditures in Figures 2-7 and 2-8, where ocean shipping appears to be much more expensive than air shipping. It is not: the higher costs incurred for ocean shipping are due to the fact that the average ocean-shipped manufactured good is 25 times heavier than the average air shipped manufactured goods. As the relative price of air/ocean shipping falls, goods at the margin shift from ocean to air shipping (Harrigan (2005) provides a formal model of this process). This point helps us to explain several patterns of modal use shown in Tables 1-3 and 1-4. There we see that the UK and Ireland use a very high ratio of air relative to sea transport. An important reason for that is that the weight/value ratio of their trade is lower than other EU countries.

As a final point, recent research has shown clearly that, within product categories, high income households buy higher quality goods. The result is that higher income countries import higher quality goods[5]. Rising incomes affect demand for transport in three ways. One, higher quality goods have higher prices and therefore a lower ad-valorem transportation cost for reasons just discussed. Two, as consumers grow richer, so does their willingness to pay for precise product characteristics.[6]. That in turn puts pressure on manufactures to produce to those specifications, and be rapidly adaptable. Three, delivery speed is itself an important characteristic of product quality, and will be in greater demand as income grows.

4.A.3. Time Costs

Delivery speed is an important characteristic of transportation quality, and increasingly, an important characteristic of the quality of the delivered good. Time in transit doesn't matter much for bulk commodities and simple manufactures. But for goods like fresh produce and cut flowers, lengthy travel times lead to spoilage. More generally, if there is uncertainty in demand plus lags between production and final sales, firms may face a mismatch between what consumers want and what the firm has available to sell. In the case of apparel, for example, firms are unable to predict in advance which fashions will be especially popular, making the ability to respond quickly to revelation of market information an important advantage. Evans and Harrigan (2003) show that clothing lines with high re-stocking rates are more likely to be obtained from exporters closest to the US market. Aizenman (2004) argues theoretically and Schaur (2006) shows empirically that the use of airplanes is an alternative solution to the timeliness problem when foreign demand is uncertain. By using a mix of ocean and air shipping firms can respond rapidly to demand shocks, essentially using airplanes as a real hedge for market volatility.

Hummels and Schaur (2008) estimate the value of time saving using US imports data that report the price and quantity of air shipping relative to ocean shipping as well as time delays associated with ocean shipping. The idea is that a firms' willingness to pay for more expensive air shipping is increasing in the number of days saved with airplanes, and decreasing in the premium paid to air ship. The sensitivity of air shipment to these factors can then be used to calculate a per day valuation for time savings that is product specific.

Call this per day valuation for an product k, τ_k. Table 4-1 (taken from Hummels, Minor, Reisman, Endean 2007) reports Hummels-Schaur estimates for various goods. As with the weight / value ratio we can then calculate the aggregate time sensitivity of a country's trade bundle by multiplying the product specific time cost by the share of that product k in the trade bundle. Since these shares differ across countries, the time sensitivity of their trade bundle will also vary. Table 4-2 (taken from Hummels, Minor, Reisman, Endean 2007) reports the per day equivalents for the import and export bundles of various regional groupings. Table 4-3 (taken from Hummels 2008) report the time sensitivity of the import and export bundle for a number of Asian countries. The values are written in ad-valorem equivalents per day. A value of 0.77 for Chinese exports means that each day of delay in transit is equivalent to a tariff of 0.77 percent, so that a 4 day delay is equivalent to a tariff of just over 3 percent ad-valorem.

Two things are notable about these figures. First, time sensitivity is much more important for the developed

5. Hallak (2005), Choi et al (2007).
6. Hummels and Lugovskyy (2005).

compared to the emerging market economies. Second, the time sensitivity of the import and export bundles are considerably different – developed markets export goods that are more time sensitive than the import, while the emerging market do the reverse. Note that the import bundles of India and Indonesia are twice as time sensitive as their exports. Of course, the numbers on time sensitivity in the last two columns of Table 4-1 are intended to capture aggregate tendencies, and do not reflect the sensitivity of particular sectors. Malaysia, for example, ships extremely time sensitive products to the US as demonstrated by the very high share of air shipping shown in the first two columns of Table 4-1.

Finally, Table 4-4 (taken from Hummels, Minor, Reisman, Endean 2007) reports the time costs of various transport delays (calculated by the World Bank Doing Business Survey) and compares these to the applied tariffs for each region. Total time costs are typically larger than tariffs, and arise from a combination of delays at ports, customs, and inland transit. Note that these numbers entirely omit costs associated with the international leg of the journey.

4.B The Changing Geography of Trade

The geography of trade, in this context, means both which partners a country trades with and what parts of a country (internal v. external) engage in trade. Partner composition matters for two important reasons First, whether a country trades with neighboring or perhaps continental partners. Second, whether a country trades with near or distant partners.

Trading with neighboring or continental partners matters enormously because it enables the use of land-based transport modes (rail, truck, pipelines). The revealed preference for land over other modes is apparent in Table 1-2 which shows the prevalence of land use, when feasible, for Latin America and the US. There are likely three reasons for this revealed preference. One, it is less expensive. For US imports from Canada and Mexico it is possible to directly compare the cost of land, air, and ocean modes, and land-based shipping incurs a smaller ad-valorem cost. Two, and perhaps related, land-based modes allow for a more granular transportation network with direct connections between production origin and consumption point. Three, land-based modes allow for smaller consignments. US imports data make clear that shipment sizes are smaller and shipment frequencies are higher when land-modes are used. This is critical in cases where initial scale is small or where demand is uncertain (more below).

Trade with near v. distance partners also matters for the choice of ocean v. air shipping when land-based modes are not an option. Suppose I am trying to decide between air and ocean shipping in reach two foreign markets, the first proximate to and the second distant from my exporter. How does the distance affect my calculation of the appropriate mode to use? Exporters consider two costs, both rising in distance. The first is the direct cost of transport, and the second is the time cost.

To measure the direct distance cost, one should compare the elasticity of air shipping costs with respect to distance to the elasticity of ocean shipping costs with respect to distance. Hummels 2007 estimates that, in 1974, the distance elasticity for air shipping costs was almost three times that of ocean shipping (.44 compared to .15). In that year, doubling distance raised air shipping prices by 44 percent while only raising ocean shipping prices by 15 percent. In other words, the direct effect of distance on the cost of shipping represented a rising penalty on air shipping. However, Hummels 2007 also estimates that the elasticity of air shipping costs with respect to distance fell steadily so that by 2004 it was virtually equal to that of ocean shipping. In this case, both air and ocean costs are rising in distance at the same rate so that distance does not affect the relative price.

Regrettably data to perform this calculation are not available after 2004. I surmise that the changing distance elasticity has much to do with the very high oil prices in 1974 and the lower prices faced thereafter. That is, the distance elasticity for air will be higher when oil prices are high. If this is correct, then I would expect that very high fuel prices from 2004-2008 would result in a distance elasticity similar to that in the 1970s.

The other cost of distance is the time cost. Choosing air transport from the UK to France might save a shipper 5 hours, while choosing air transport from China to France might save 5 weeks. How does a shipper balance the direct cost against the time costs? The answer is product specific and provided by Hummels and Schaur (2008) – see above. However, a general statement is that an air premium may be worth paying to save 5 weeks, but not 5 hours. That is, at short distances the direct cost wins out while at longer distances (and for time sensitive goods) the time cost dominates. This is likely why air shipping is used far less extensively for intra-continental trade than for trade at a longer distance.

As a final point, geographic remoteness of another kind can be overcome by using airplanes. Ocean port cities act as entrepots for interior regions of their own countries. These entrepot cities can be a bottleneck choking off trade, especially for geographically large countries with economically important interior regions. This becomes more pronounced in cases where ports vie for land and coastal access that retains significant value for housing and public amenities. Trucks arriving at and departing these facilities also compete with other users of roadways, leading to major highway congestion and significant pollution effects. Air cargo that overflies congested ports can be an effective way to reach remote interior regions. This can be seen clearly in US data, where the share of coastal facilities is shrinking in favor of direct transport into the US interior[7].

4.C. The Changing Organization of Production.

4.C.1. Vertical Specialization and Global Supply Chains.

A hallmark of recent trade growth is the fragmentation of international production processes, also known as vertical specialization, slicing up the value chain, or unbundling supply chains[8]. What it is called, it simply means that production of certain manufactured goods takes place in multiple distinct stages and these stages are increasingly geographically dispersed.

How important is this phenomenon? One way to measure the fragmentation process is to look at the share of trade that occurs in goods labeled “parts and components”. This approach has been widely employed and is useful, but it also leaves out intermediate goods (e.g. chemicals) that do not contain the “parts and components” label. An alternative approach introduced in Hummels, Ishii and Yi (2001) is to employ input-output tables that track use of imported intermediate inputs. Hummels and Puzzello (2008) use this approach in conjunction with the Asian Input-Output data produced by IDE-JETRO for 1975-2000. Table 4-5 taken from their work, shows the growth in input trade from 1975-2000, both relative to gross output and relative to total trade. The use of imported inputs as a share of gross output has grown enormously – more than 300% in Malaysia, Thailand, and the Philippines. Input trade as a share of total trade is now 60-70 percent for most of Asia.

Scholars have provided several theoretical explanations for the growth in fragmentation. Broadly speaking, these theoretical treatments argue that each country enjoys a comparative advantage in a different stage of production (R&D, production of various parts and components, assembly) and so in a world of frictionless trade, each country would specialize in that stage. However, if moving goods (and people and ideas) around is costly, then fragmentation will be costly. This creates a tension for firms – separating stages can lower production costs for each stage but raise the costs of transport and coordination. When comparative advantage is strong the first force wins out and fragmentation increases. When trade costs rise the second force wins out and fragmentation decreases. Yi (2003) notes that because products engage in “round tripping” – with inputs being shipped multiple times as components of complex manufactures are gradually built up into an assembled final product – the impact of transport costs are multiplied by the number of times a component in shipped. As a result, small reductions in costs over time can yield large increases in fragmentation and trade as a whole.

7. Haveman and Hummels (2004)
8. The phenomenon appears to have as many names as authors writing about it.

It should be said, however, that empirical evidence on the causes of rising fragmentation is fairly weak. The most direct evidence (that this author knows of) comes from Hummels and Puzzello (2008), who control for variation in expenditures by using industry to show that input trade is vastly more "home-biased" than final goods trade. In addition, input trade is far more likely to take place with neighboring countries and with partners that share a common language. However, all these effects were quite strong from 1975-1995, they have weakened substantially from 1995-2000.

More speculatively, I would point to three key factors explaining the rise in fragmentation. First, information technology makes it easier for firms to communicate information between stages of production. This information could take the form of blue prints, quality validation, or inventory management. Second, coordinating production requires moving managers and engineers between far flung production plants, and this is greatly aided both by lower air passenger rates (through 2000), and by a greater density of air connections. Third, timeliness in delivery is critical as entire factories can be shuttered by the absence of key components and achieving timeliness in delivery is greatly assisted by lower air cargo costs (again, through 2000).

These three points suggest that fragmentation puts a much larger strain on transport and trade infrastructure than other types of production arrangements. Put another way, fragmentation is extremely transportation-intensive. Fragmented products move multiple times rather than once. Fragmented products use airplanes more intensively than container ships. Fragmented production processes require frequent shuttling of executives and engineers around the globe. As such, these processes may be quite sensitive to rising fuel costs after 2000 and greatly curtailed by it, though it will be some time before data are available to test this hypothesis.

4.C.2. "Small value" trade and Testing Markets

Recent theoretical and empirical research in international trade has begun to emphasize the importance of extensive and intensive margins of trade expansion. A country can expand exports by trading larger quantities of a given set of goods (the intensive margin), or by expanding set of goods that are traded (the extensive margin). Higher trade costs can affect both margins[9].

For example, suppose that exporting firms must pay a fixed cost of trade (for example, the cost of collecting information about foreign markets or setting up distribution networks) and marginal costs of trade (proportional to quantities traded). In this case, firms must sell a sufficiently high volume of exports to justify paying the fixed costs. A fall in marginal costs of trade lowers delivered prices and expands quantities demanded abroad. This has two effects: existing exporters can sell larger quantities (an increase in the intensive margin), and more firms can now cover their fixed costs of trade and begin exporting for the first time (an increase in the extensive margin). In contrast, a drop in fixed costs of trade leads to trade expansion only along the extensive margin.

9. See Hummels and Klenow (2005) on extensive and intensive margin expansion and Hillberry and Hummels (2007) and Eaton, Kortum, and Kramarz (2004) on the role of geographic frictions.

Which of these are most important? In order to decompose trade growth in this manner, write the aggregate value of a country c's exports at time t as

(0.3) $$X_t^c = N_{jkt}^c \bar{X}_{jkt}^c$$

N_{jkt}^c is the number of unique shipments of products k (measured at the 6 digit level of the Harmonized System) to destinations j from exporter c at time t, and $\bar{X}_{jkt}^c$ is the average value per unique shipment. If c ships 10 distinct products apiece to each of 5 destination markets the number of unique shipments is 50[10]. Exports could increase over time because country c ships more goods, has more export destinations per good or higher average value per shipment. (Note that it is also possible to separate N into the number of products and number of destinations per product. However, at this 6 digit HS level of aggregation we see very little growth in number of products traded in this period. As a result, changes in the number of unique shipments for these countries and this time period are driven almost entirely by expansions in the number of markets with which trade occurs.)

We can then express the log percentage change in total exports over time as the sum of the log changes in the components, that is

$$\ln \frac{X_{t+1}^c}{X_t^c} = \ln \frac{N_{jkt+1}^c}{N_{jkt}^c} + \ln \frac{\bar{X}_{jkt+1}^c}{\bar{X}_{jkt}^c}$$

This is useful because we can then assess the percentage contribution of each component to the total change.

Table 4-6 provides this decomposition for Mexico's very rapid export expansion from 1991-2004. In this period Mexican exports to the US increased dramatically, a log percentage change of 1.374. How did this growth occur? If we define goods using the HS 6 classification, the answer is: primarily along the intensive margin. The mean value per shipment grew by 1.145 log points, and number of goods grew by only .228 log points. That is, 83 percent (=1.145/1.374) of export growth was along the intensive margin and 17 percent was along the extensive margin. However, if one disaggregates down to 10 digit categories, then the extensive margin growth becomes much more apparent. In this case, almost 30 percent of the growth is in new products.

Table 4-7 (taken from Hummels 2008) provides a similar decomposition separately for imports and exports of each Asian country. For simplicity I report only the log change in each variable. For example, the log change in Chinese exports between 1995 and 2005 is ln(675/161)=1.43. Of this 1.43, 0.80 came from an increase in the number of unique shipments, and 0.63 came from an increase in average value per shipment. Contrast this mixed growth with Thailand and Malaysia where almost all growth came via an increase in the number of shipments rather than an increase in the average shipment. Conversely, almost all the growth for Hong Kong and Japan came through an increase in average shipment size rather than an increase in the number of unique shipments.

The calculation of the changes in average shipment size can be misleading – the average can rise because all existing shipments get larger, or it could be that shipment size grows differentially at different points in the size distribution. To show this distinction Table 4-7 also reports growth in the size of the median and 90th percentile shipment. By comparing these to growth in the mean shipment we can understand where trade growth is occurring.

Consider Chinese exports, where the number of shipments and mean shipment size are growing rapidly, as are 90th percentile shipments, but median shipment sizes are falling. This indicates that China has

10. One could further decompose this into the number of products multiplied by the average number of destinations per product.

experienced a tremendous growth in new shipments but these tend to be very small, pushing down the median shipment size. At the same time, established flows that were already large (90^{th} percentile) in 1995 have grown larger still, and this increased the mean shipment size. The pattern across all reported countries is similar – median shipment sizes are falling while mean shipment sizes are rising (or in some cases, both are falling but medians are falling faster).

What do we learn from this exercise? For most of these countries we have export expansion occurring in two very different ways – there are large and existing flows that are the principal drivers of aggregate trade growth, but there are also a very large number of new entrants that, to date, do not yet represent a large fraction of overall trade. This distinction matters for several reasons. One, the infrastructure needs of small and medium size firms may be considerably different than those of large firms. They typically lack the internal capacity for facilitating trade and must work through trade intermediaries to gather information about foreign market opportunities, and to handle trade finance, transportation and distribution functions. Two, small firms face higher shipment costs because they are unable to negotiate bulk discounts. Three, if we take the fixed v. marginal cost view of trade costs, these new flows associated with small and medium size firms are highly tenuous. Small increases in trade costs could kill off many exporting firms quickly. Now, one could view this as a minor concern – these flows are small and their loss could be absorbed with little impact on aggregate numbers – but this ignores the dynamic nature of new flows. Besedes and Prusa (2003,2004) use survival analysis to show that new trade flows suffer high failure rates, but those that do survive go on to ever-larger trade shares. That is, today's success story was yesterday's fragile newborn.

Putting all this together it suggests that nations are increasingly growing their exports by shipping new goods to new markets. What are the characteristics of these new markets? Most firms begin producing only for a local market, slowly expand sales within their own country, and some small fraction of these gradually expand sales abroad. Of these who go abroad, they initially look to neighboring countries. Because of this process, new and unexploited markets tend to be further away. When serving these distant markets, firms face tremendous uncertainty about demand, quantities sold are likely to be very low initially, and most trading relationships fail in a few years. All of these characteristics, initially small quantities of uncertain demand in distant markets, are precisely the characteristics that make air shipping particularly attractive. This suggests that airplanes may be an especially effective tool for firms wishing to test new markets[11].

5. Looking Forward: Future Trends in the Short and Long Run

Guessing at future trends is always hazardous. I will start with the recent short term disruptions due to the financial crisis and economic slowdown of 2008. I will then turn to long run trends and discuss their implications for transportation prices and demand. It should be understood that this forward look is not based on any formal forecasting model but rather based on the author's qualitative evaluation of trends.

5.A. Short Run Trends

As this report is being written in Fall 2008, a severe financial crisis in the US has rippled outwards with significant effect on world financial markets. At the same time, economic growth on the real side of the economy is slowing. How will this affect trade and transportation demand?

Trade and the Business Cycle

Simply put, trade drops during recessions as income falls and the consumption share of income drops. This can have a pronounced effect on those countries whose exports are tied closely to a single importing market. For example, Mexico's exports to the US tripled from 1994-2000, but declined for three years as a

11. Aizenman (2003) and Schaur (2006) examine the use of airplanes in hedging demand volatility. Evans and Harrigan (2005) and Harrigan and Venables (2004) discuss the importance of demand volatility in determining comparative advantage and industrial agglomerations.

consequence of the 2001 recession in the US. These effects are more likely to be pronounced when the recession is global, rather than isolated in a single country. When a country slides into recession by itself, there is a quick remedy in the form of currency depreciation and export growth to stimulate aggregate demand. But when multiple economies slide into recession simultaneously the prospects for an export-led recovery are dimmed. This effect may be exacerbated by the tendency for economies sliding into recession to look for any and all available means to boost output for their domestic industries. This makes short term protectionist measures very attractive.

Oil Prices

Output responses will be more muted when prices adjust. Falling demand shows up in falling prices, and nowhere is this more apparent than in the precipitous drop in oil prices in the second half of 2008. While this channel should indirectly boost trade and transportation demand, it is clearly a second order effect relative to the first order income shocks.

The Composition of Trade

Two of the recent trade trends outlined above become more problematic when output is contracting and income is dropping. First, Alessandria, Kaboski and Midrigan (2008) show theoretically and empirically that "small value" trade, and the extensive margin of trade, is especially sensitive to demand declines. That is, demand declines cause trade to contract, but the effect is especially pronounced for firms that had small trade volumes prior to the contraction. They are focused primarily on the effect of large real exchange rate depreciations but the point goes through for recessionary contractions. Second, speed is a luxury good. Overnight delivery of goods may be an easy thing to give up when income is tight. This seems likely to translate into a reduction in the demand for express air transport.

5.B. Long Run Trends

China and India will continue to grow

In the last decade China and India have experienced dramatic economic growth that has fueled a tremendous rise in trade volumes within Asia and the rest of the world. The major drivers of that growth, factor accumulation and technological progress, show no signs of abating. It is possible that China in particular will rely less on export-led growth, but the scope for inward-looking growth is large as development and infrastructure continues to spread inland. This may result in slower growth in export volumes, but Chinese demand for imported commodities necessary for infrastructure development should continue. This translates into demand for bulk carriers to move those commodities from production sources in Asia, Latin America and Africa.

Oil prices will continue to rise

Barring discovering of major new oil reserves or alternative energy sources, rising consumption of energy will push prices steadily upwards. The "International Energy Outlook 2008" produced by the US Energy Information Agency forecasts a 50 percent rise in world energy consumption, with an 85 percent rise for non-OECD countries. This outlook forecasts roughly linear increases in demand and supply, but with demand growing faster. The result is forecasted to be rising oil prices, reaching as high as $186 by 2030. (This forecast was authored prior to the dramatic run up in oil prices in the second quarter of 2008; it is not known how that experience would translate into differences in the forecast.)

In short, this forecast calls for the steady increase in oil prices experienced between 2000-2007 (see Table 3-1) to continue for the next 25 years. This scenario includes no provision for rising taxation of fossil fuels. Were global efforts to limit greenhouse gas emissions to result in significant fuel taxes one would expect these price increases to be even greater.

Recalling the discussion in section 3, rising fuel prices result in higher transportation costs regardless of mode. However, the elasticity of transportation costs with respect to fuel prices is much higher for commercial aviation than for ocean-borne cargo. This means that, absent some unseen technological innovation, rising fuel prices will continue to increase the relative price of airborne cargo.

US current accounts must come back into balance.

The US has for almost three decades run current account deficits, and these deficits have grown to historically unprecedented magnitudes: over $800billion in each year from 2005, 2006, 2007. It is hard to find an international economist who believes this situation can continue. At some point, net foreign capital flows into the US will slow (perhaps aided by an increased perception of risk in US capital markets), the US dollar will fall in value and the massive trade gap will narrow. This process is already underway in 2008, but seems likely to accelerate.

Consider the difference in freight rates on routes to and from the US displayed in Table 3-1. Rates on Asia to US routes are more than double rates for the return voyage. Rates on Europe to US routes are roughly 50 percent greater than rates on the return voyage from the US to Europe. While there may be additional factors that drive this enormous disparity, the enormous US trade deficit seems a likely primary cause. Indeed, the trade deficit may actually understate the imbalance in ocean cargoes, as US exports are significantly more air-intensive than are US imports. Data on capacity utilization on US inbound v. outbound routes were not available to this author. However, the macroeconomic facts on the trade deficit along with the very large differences in rates on these routes suggests that containerships inbound to the US steam at full capacity with significant slack capacity on return routes.

If, then, the US dollar were to depreciate and the US trade deficit to narrow or even reverse itself, the result would necessarily be a size-able rebalancing on the cargo front. The obvious effect would be to equalize the rate differential between inbound and outbound cargos. Less obviously, and perhaps more speculatively, I expect that a narrowing of the US trade deficit would allow a reduction in ship capacity deployed on these routes. To explain, consider a simple example. Suppose the US has 15m containers of gross trade, with 10m containers imported and 5m containers exported through the combined Los Angeles/Long Beach facilities. The imports would require 2000 round trips by 5000 TEU containerships, with those same ships returning on westbound routes half empty. Now, suppose the US were to balance trade, with 7.5m containers imported and exported, for the same 15m containers of gross trade. The same gross volume of trade could be handled with 1500 visits of 5000 TEU ships for a 25% reduction in shipping capacity.

Protection

There is ample evidence to show that reductions in tariff barriers to trade have resulted in sharp increases in trade volumes. For example, Mexican exports to the US tripled in the 6 years after signing NAFTA, and China's exports to the world quadrupled in the 5 years after its WTO accession.

However, the forecast for further liberalization seems cloudy at best with the Doha round of WTO talks now entering its eighth year of negotiation, and several preferential trade agreements similarly stalled. And barriers once removed can easily become barriers reinstated. While it is hard to imagine many countries pulling out of existing agreements, there is no shortage of disputes that could provide a pretext for administered protection for governments so inclined. A short list of examples would include disputes over product health and safety, intellectual property protection, and labor and environmental standards.

Predicting what will happen in this area is extremely difficult, but it would not surprise this author were we to see significant backsliding on the trade liberalization front.

Firms and persons will pursue alternative channels for realizing gains from trade.

International trade economists point out that there are frequently multiple ways for an economy to enjoy the gains from trade without actually engaging in merchandise trade itself. Consider some examples. Countries with high capital/labor ratios will have a lower cost of capital and can gain from trade by exporting capital-intensive goods while importing labor-intensive goods. Alternatively, the same gains from trade can be accomplished by capital flows or migration than narrow gaps in capital/labor ratios. Countries may also have a comparative advantage in certain goods because their firms enjoy a productivity advantage in their production. Similarly, much trade is driven by consumer and firm love of variety, that is, enjoyment of distinct differentiated goods produced around the world. In both cases firms can produce those goods in their home markets and export them to consumers worldwide. Alternatively, they can trade the technology itself (selling blueprints, engaging in FDI) so that the goods can be produced in the consumers' home markets anywhere in the world.

The broad point here is that there are many ways to engage in international arbitrage, and firms will tend to pursue the channel that is most efficient. Three factors point toward growth in channels other than merchandise trade. First, starting with the Uruguay round of the GATT/WTO new trade agreements have focused more on liberalization of investment, services trade, and intellectual property protection than on liberalizing merchandise trade. Second, dramatic improvements in information technology allow firms to share technology and coordinate production worldwide. Third, trade costs for merchandise trade seem likely to rise, both transportation costs (due to oil prices) and political barriers to trade such as tariffs. A consequence is that countries will enjoy the benefits of trade without physically moving merchandise.

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List of Tables and Figures

Table 1-1 -- How Goods Move

	World Trade All Goods (2000 US$bn)	World Trade All Goods Million Tons	World Trade Manufactures (2000 US$bn)	World Trade Quantities of Non-bulk cargoes: Million tons Ocean	Million tons Air	Billion ton-miles Ocean	Billion ton-miles Air	US: Air share of trade value excluding N America: Imports	Exports
Year									
1951			179				0.2		
1955	505	880	222				0.3		
1960	623	1080	301	307			0.7		
1965	844	1640	453	434		1537	1.8	8.1	11.9
1970	1152	2605	684	717		2118	4.3	12.1	19.5
1975	2341	3072	1307	793	3.0	2810	7.7	12.0	19.3
1980	3718	3704	2009	1037	4.8	3720	13.9	13.9	27.6
1985	2759	3382	1683	1066	6.5	3750	19.8	19.8	36.3
1990	4189	4008	2947	1285	9.6	4440	31.7	24.6	42.3
1995	5442	4651	4041	1520	14.0	5395	47.8	33.1	44.3
2000	6270	5983	4688	2533	20.7	6790	69.2	36.0	57.6
2004	8164	6758	6022	2855	23.4	8335	79.2	31.5	52.8
Annualized Growth Rates									
Whole sample	7.40	5.37	7.04	5.20		4.43	11.72	3.55	3.89
1975-2004	4.40	2.76	5.41	4.52	7.37	3.82	8.35	3.40	3.53

Notes:

1. World trade data from WTO, "International Trade Statistics, 2005" and authors calculations
2. World air shipments from IATA World Air Transport Statistics
3. World ocean shipments from UNCTAD Review of Maritime Transport
4. US data from US Statistical Abstract, US Imports of Merchandise; US Exports of Merchandise

Table 1-2: Latin American Imports: Transport Mode

Selected LAC Countries and US. 2005 (%)

	From All Countries				From LAC			
Country	Air	Maritime	Land	Others	Air	Maritime	Land	Others
Brazil	24.6	67.5	5.8	2.1	4	51.3	37.5	7.2
Colombia	27.9	59.0	8.8	4.3	18.6	61.1	16.9	3.4
Argentina	17.2	52.9	23.6	6.3	10.6	43.1	43.8	2.5
Bolivia	14.4	0	80.6	5.0	6.7	0	86.9	6.4
Chile	13.5	65.7	15.7	5.1	7.3	42.1	37.5	13.1
Ecuador	16.5	73.6	8.9	1.0	11.1	65.8	18.4	4.7
Mexico	8.2	20.5	55	16.3	5.3	66.4	12.9	15.4
Peru	13.8	82.1	3.7	0.4	6.6	86	6.9	0.5
Paraguay	10.7	0	45.8	43.5	2.4	0	77	20.6
Uruguay	7.9	49.4	25.7	17.0	4.1	21.6	46.6	27.7
Venezuela	19.6	70.9	9.4	0.1	14.1	59.8	26.0	0.1
LAC*	15.8	49.2	25.7	9.2	8.3	45.2	37.3	9.2
US	21.6	51.6	26.7		-			

Note: Data for Argentina and Bolivia is for 2004. * Simple average

Source: Moreira 2008 based on ALADI data and US Census Bureau.

Table 1-3 European Import Values by Transport Mode

	Value Share in 2007 (mil. Euro)				Change in Share 2000-2007				% Change in value 2000-2007			
	air	sea	rail & road	other	air	sea	rail & road	other	air	sea	rail & road	other
EU 27	18.1	50.3	14.7	16.9	-7.0	8.8	-0.5	-1.3	4	75	39	34
Austria	16.2	23.2	38.3	22.3	-8.4	-1.2	3.8	5.8	4	51	76	114
Belgium	21.7	55.1	18.9	4.2	-9.2	12.0	-3.9	1.1	10	100	30	115
Bulgaria	3.0	52.4	34.0	10.6	-2.0	2.3	8.9	-9.3	71	197	284	51
Cyprus	9.8	90.0	0.0	0.2	-2.6	18.2		-15.7	13	78		-99
Czech Republic	9.6	0.1	65.5	24.8	-2.2		5.5	-3.4	63		118	75
Germany	24.5	40.6	18.0	16.9	-5.2	9.0	-4.1	0.3	12	75	11	38
Denmark	13.9	52.7	26.7	6.7	-1.2	-7.9	8.8	0.2	30	22	110	46
Estonia	10.3	31.7	51.9	6.1	2.3	0.3	-4.8	2.2	130	81	64	182
Spain	8.1	77.8	7.4	6.7	-4.3	1.2	0.0	3.2	26	96	93	270
Finland	22.0	56.2	16.2	5.6	-5.4	11.2	-6.0	0.1	40	118	27	79
France	18.4	56.3	14.7	10.6	-6.4	15.7	-0.9	-8.3	-14	60	9	-35
United Kingdom	32.0	54.6	0.0	13.3	-10.5	15.0	0.0	-4.4	-14	57	0	-15
Greece	8.1	68.1	13.5	10.3	-1.5	-5.0	-0.1	6.6	55	71	83	407
Hungary	21.2	0.5	57.7	20.6	16.7		14.3	-31.5	775		149	-26
Ireland	39.3	47.5	8.4	4.8	-17.1	5.1	7.2	4.8	-37	1	567	24711
Italy	9.5	67.5	12.3	10.6	-5.9	7.4	-5.6	4.0	-3	76	8	153
Lituania	4.5	51.3	33.2	11.1	0.8	40.7	-9.8	-31.7	168	964	70	-43
Luxemburg	81.3	10.7	7.6	0.5	26.2	-2.1	-17.8	-6.2	299	125	-19	-82
Latvia	5.7	27.2	55.7	11.5	-1.0	16.6	-3.1	-12.5	140	627	167	35
Malta	57.9	42.1		0.0	-7.5	7.6		-0.1	-48	-28		-100
Netherlands	8.4	34.8	6.5	50.3	1.9	1.3	0.3	-3.4	109	69	70	52
Poland	8.8	37.5	28.4	25.4	0.7	24.2	-18.6	-6.2	114	457	19	59
Portugal	9.7	84.9	4.9	0.6	-4.9	8.4	-0.4	-3.1	-9	52	27	-79
Romania	5.3	48.8	33.5	12.5	-1.6	9.8	-12.5	4.3	133	280	121	362
Sweden	15.4	54.0	28.0	2.6	-14.8	5.1	8.2	1.6	-34	42	82	237
Slovenia	6.0	44.6	43.5	5.9	-2.9	30.4	-25.8	-1.7	62	652	51	85
Slovakia	14.6	29.7	25.9	29.9	12.3		-21.3	-20.7	1682		53	65

Table 1-4 European Export Values by Transport Mode

country	Value Share in 2007 air	sea	rail & road	other	Change in Share 2000-2007 air	sea	rail & road	other	% Change in value 2000-2007 air	sea	rail & road	other
EU 27	25.1	43.7	25.6	5.7	-5.9	1.2	5.0	-0.4	20	52	85	39
Austria	17.4	31.3	49.4	1.9	-7.1	5.9	0.4	0.8	30	126	84	221
Belgium	40.3	33.2	25.1	1.4	-4.9	0.1	4.3	0.5	42	60	92	133
Bulgaria	4.4	42.4	47.8	5.4	1.0	9.8	-6.0	-4.8	223	223	121	31
Cyprus	41.9	58.0	0.0	0.1	10.9	-10.9		0.0	142	51		47
Czech Rep	13.2	15.6	64.2	7.0	4.9		-25.3	4.7	396		123	861
Germany	21.9	43.9	26.4	7.8	-4.0	1.2	2.4	0.5	38	68	79	73
Denmark	22.8	51.2	22.7	3.3	0.6	-5.3	3.3	1.4	41	24	61	135
Estonia	4.4	50.4	44.8	0.4	-0.2	-10.1	11.1	-0.8	460	388	678	86
Spain	14.9	66.2	15.2	3.6	0.2	-5.0	2.8	2.0	61	48	95	258
Finland	22.6	43.2	30.7	3.4	-8.0	-1.9	10.8	-0.9	14	48	138	23
France	25.2	38.7	20.4	15.7	-3.2	5.2	2.1	-4.1	2	32	27	-9
United King	43.7	51.3	3.2	1.8	-4.2	1.1	2.2	0.8	-2	10	254	103
Greece	5.0	61.6	33.0	0.4	-6.5	9.6	-3.0	-0.1	-41	62	26	13
Hungary	16.2	0.5	78.4	4.9	10.7		15.0	-26.2	849		298	-49
Ireland	62.6	35.8	1.1	0.5	-4.4	3.3	0.6	0.5	3	21	147	119463
Italy	17.6	52.3	26.8	3.3	-4.4	0.6	1.3	2.5	16	47	53	480
Lituania	3.0	23.6	62.3	11.1	-1.8	9.0	-11.0	3.8	186	634	288	592
Luxemburg	17.7	35.3	39.8	7.1	-1.6	1.9	-7.1	6.8	48	71	37	3007
Latvia	4.0	22.4	70.9	2.7	-0.3	-21.3	20.1	1.5	305	121	501	881
Malta	79.6	20.4	0.0	0.0	-7.0	7.0		0.0	-44	-7		594
Netherland	26.3	43.9	26.7	3.2	-0.5	6.9	-2.7	-3.7	83	121	70	-14
Poland	4.4	28.8	61.8	5.0	-1.5	2.1	4.3	-4.9	160	278	277	77
Portugal	28.1	63.8	8.0	0.1	7.6	-2.2	-1.8	-3.7	150	76	48	-97
Romania	2.5	53.8	31.1	12.7	-0.7	-7.5	3.1	5.0	108	134	196	343
Sweden	23.0	43.4	31.8	1.8	-16.3	5.4	9.8	1.2	-25	46	84	255
Slovenia	4.3	11.0	80.2	4.5	0.0	10.7	-14.5	3.8	166	8625	123	1596
Slovakia	5.0	34.0	57.0	4.0	3.2		-38.0	0.8	1166		170	455

Table 1-5 European Import Weights by Transport Mode

	Weight 2007 (000 tonnes)				Weight Share 2007 (000 tonnes)			
country	air	sea	rail & road	other	air	sea	rail & road	other
EU	16430	5064247	574934	1552580	0.2	70.3	8.0	21.5
Austria	196	15713	18776	62949	0.2	16.1	19.2	64.5
Belgium	702	275264	20254	58744	0.2	77.5	5.7	16.5
Bulgaria	21	60426	15231	11405	0.0	69.4	17.5	13.1
Cyprus	21	12542	2	1	0.2	99.8	0.0	0.0
Czech Republic	63	22	34484	50821	0.1	0.0	40.4	59.5
Germany	3181	439225	49902	474249	0.3	45.4	5.2	49.1
Denmark	190	64171	3979	28010	0.2	66.6	4.1	29.1
Estonia	14	5545	13045	815	0.1	28.6	67.2	4.2
Spain	770	751447	4703	45850	0.1	93.6	0.6	5.7
Finland	102	100048	49484	15193	0.1	60.7	30.0	9.2
France	1617	582923	21063	70565	0.2	86.2	3.1	10.4
United Kingdom	6219	689015	94	74207	0.8	89.5	0.0	9.6
Greece	86	124445	12861	12801	0.1	82.9	8.6	8.5
Hungary	251	102	42294	53625	0.3	0.1	43.9	55.7
Ireland	204	48783	2049	89	0.4	95.4	4.0	0.2
Italy	978	887608	25440	176948	0.1	81.4	2.3	16.2
Lituania	10	25841	26350	9710	0.0	41.7	42.6	15.7
Luxemburg	257	287	949	5	17.1	19.1	63.4	0.3
Latvia	8	4030	15619	4661	0.0	16.6	64.2	19.2
Malta	7	1253		0	0.5	99.5		0.0
Netherlands	656	604108	12000	256822	0.1	69.2	1.4	29.4
Poland	189	51599	92885	79514	0.1	23.0	41.4	35.5
Portugal	100	119648	664	53	0.1	99.3	0.6	0.0
Romania	42	79645	31909	14361	0.0	63.2	25.3	11.4
Sweden	345	104080	22057	671	0.3	81.9	17.3	0.5
Slovenia	12	14517	14638	8720	0.0	38.3	38.6	23.0
Slovakia	189	1961	44203	41792	0.2	2.2	50.1	47.4

Table 1-6 European Export Weights by Transport Mode

	Weight 2007 (000 tonnes)				Weight Share 2007			
country	air	sea	rail & road	other	air	sea	rail & road	other
	44942	1487690	484402	103226	2.1	70.2	22.8	4.9
Austria	297	13932	30899	2089	0.6	29.5	65.4	4.4
Belgium	2567	115340	31563	7498	1.6	73.5	20.1	4.8
Bulgaria	209	26075	14886	2956	0.5	59.1	33.7	6.7
Cyprus	168	1544	0	0	9.8	90.2	0.0	0.0
Czech Republic	270	2385	13974	1314	1.5	13.3	77.9	7.3
Germany	5341	178407	97939	39237	1.7	55.6	30.5	12.2
Denmark	215	25034	4101	637	0.7	83.5	13.7	2.1
Estonia	207	9850	4103	15	1.5	69.5	28.9	0.1
Spain	12512	142640	12531	3380	7.3	83.4	7.3	2.0
Finland	205	42435	13658	496	0.4	74.7	24.0	0.9
France	13009	135875	40934	11380	6.5	67.5	20.3	5.7
United Kingdom	1669	181364	1201	1153	0.9	97.8	0.6	0.6
Greece	911	38788	10887	24	1.8	76.6	21.5	0.0
Hungary	458	63	32674	2813	1.3	0.2	90.7	7.8
Ireland	201	10085	66	25	1.9	97.2	0.6	0.2
Italy	1884	186226	38252	2840	0.8	81.2	16.7	1.2
Lituania	23	10937	8108	989	0.1	54.5	40.4	4.9
Luxemburg	61	2224	772	408	1.8	64.2	22.3	11.8
Latvia	108	3182	2964	7	1.7	50.8	47.3	0.1
Malta	18	395		0	4.3	95.7		0.0
Netherlands	1933	185148	23284	11235	0.9	83.6	10.5	5.1
Poland	287	24781	42149	2231	0.4	35.7	60.7	3.2
Portugal	1258	24853	884	7	4.7	92.0	3.3	0.0
Romania	114	42794	8475	7814	0.2	72.3	14.3	13.2
Sweden	973	78721	27775	2236	0.9	71.8	25.3	2.0
Slovenia	16	3418	10984	1828	0.1	21.0	67.6	11.3
Slovakia	29	1194	11340	613	0.2	9.1	86.1	4.7

Table 1-7 Modal Shares within Europe

	Shares in 2006			Change in shares 1990-2006			
	Road	**Rail**	**IWW**	**Road**	**Rail**	**IWW**	
EU 15	79.1	14.4	6.5	5.8	-3.9	-1.9	*
Austria	63.2	33.8	3.0	14.2	-11.1	-3.1	
Belgium	71.2	14.0	14.7	-2.0	-2.4	4.2	*
Cyprus	100.0	0.0	0.0	0.0	0.0	0.0	
Denmark	91.8	8.2	0.0	0.8	-0.8	0.0	
Finland	72.7	27.1	0.2	-2.2	3.3	-1.1	
France	80.9	15.7	3.4	7.6	-7.2	-0.5	*
Germany	65.9	21.4	12.8	7.3	-3.2	-3.9	*
Greece	98.1	1.9	0.0	2.3	-2.3	0.0	*
Iceland	100.0	0.0	0.0	0.0	0.0	0.0	*
Ireland	98.8	1.2	0.0	9.1	-9.1	0.0	
Italy	90.1	9.9	0.0	3.0	-3.0	-0.1	*
Latvia	39.0	61.0	0.0	16.6	-16.0	-0.6	*
Lithuania	58.4	41.6	0.0	31.0	-30.4	-0.6	
Luxembourg	91.5	4.6	4.0	16.6	-11.9	-4.5	
Malta	100.0	0.0	0.0	0.0	0.0	0.0	
Netherlands	63.6	4.1	32.3	3.4	0.9	-4.3	*
Poland	70.4	29.4	0.2	37.6	-37.1	-0.5	
Portugal	94.9	5.1	0.0	3.1	-3.1	0.0	*
Romania	70.5	19.4	10.0	34.3	-41.7	7.4	
Slovenia	78.2	21.8	0.0	24.4	-24.4	0.0	
Spain	95.4	4.6	0.0	6.1	-6.1	0.0	*
Sweden	64.5	35.5		6.4	-6.4	0.0	
United Kingdom	88.1	11.8	0.1	-1.9	1.9	0.0	*

* First period of data is 1991.
Source: Eurostats

Table 2-1 Ad-valorem Transportation Costs for the US, Latin American and the Caribbean

	US	Argentina	Bolivia	Brazil	Chile	Ecuador	Paraguay	Peru	Uruguay
Aggregate freight expenditures (% of imports value)									
All exporters	3.5%	5.9%	8.4%	5.7%	8.1%	9.2%	9.7%	8.5%	5.8%
OECD exporters	2.6%	5.7%	8.6%	5.2%	6.8%	8.4%	9.9%	8.3%	6.7%
Non-OECD exporters	4.5%	6.2%	8.1%	6.2%	9.6%	10.1%	9.4%	8.6%	5.5%
Freight: % of total trade costs	85.0%	31.3%	45.7%	31.0%	42.4%	45.5%	63.0%	39.5%	31.5%
Coefficient of variation in ad-valorem transportation costs across goods	1.4	5.24	1.83	1.34	1.7	1.68	1.64	1.28	1.59
Coefficient of variation in ad-valorem transportation costs across exporters	0.89	0.82	0.71	0.95	0.81	0.86	0.72	0.82	0.59

source: Hummels, Lugovskyy, Skiba (2008)

Table 2-2 -- Changing Air Fares by Region
(annualized growth rates)

	Shipping price *per kg (2000$)*		Ad-valorem Air Freight Rate		Distance Premium
years	1973-80	1980-93	1973-80	1980-93	1973-93
All Routes	2.87	-2.52	-4.37	-1.70	-0.66
Developed Nation Routes					
North Atlantic	1.03	-3.59	-6.08	-2.77	-1.37
Mid Atlantic	3.45	-3.36	-3.83	-2.55	-1.72
S Atlantic	3.98	-3.92	-3.33	-3.11	1.23
North and Mid Pacific	-3.43	-1.48	-10.22	-0.64	-0.42
South Pacific	-2.49	-0.98	-9.35	-0.14	-0.41
Developing Nation Routes					
North to Central America	3.63	-0.72	-3.66	0.11	-0.57
North and Central America to South America	2.34	-1.34	-4.86	-0.44	-1.98
Europe to Middle East	4.80	-3.02	-2.57	-2.20	0.47
Europe and ME to Africa	1.84	-2.34	-5.33	-1.51	-2.38
Europe/ME/Africa to Asia/Pacific	3.32	-2.78	-3.95	-1.96	0.86
Local Routes					
Local Asia/Pacific	0.97	-1.52	-6.13	-0.69	-1.84
Local North America	1.63	-1.73	-5.52	-0.90	-1.09
Local Europe	4.51	-2.63	-2.84	-1.81	-1.38
Local Central America		0.97		1.82	-1.11
Local South America	2.53	-2.25	-4.68	-1.42	0.58
Local Middle East	1.92	-1.46	-5.25	-0.63	-0.24
Local Africa	4.94	-2.43	-2.44	-1.60	-0.06

Notes:
(1) All series expressed in terms of annualized growth rates.
(2) Price per kg and ad-valorem freight rate series constructed using mean shipping distance within that route group
(3) Price per kg deflated using US GDP deflator. Ad-valorem rates constructed using a price per kg import price index.
(4) Distance premium equals ratio of freight rates at distances equal to twice and one-half mean distance within that group
(5) Local series do not include domestic flights.

Table 2-3 Inland Costs of Transporting One TEU Container

	Imports			
	Total	Inland	Ports	Other
East Asia & Pacific	519	27%	30%	44%
Europe & Central Asia	1952	60%	9%	31%
High income: OECD	904	47%	25%	28%
Latin America & Caribbean	1385	42%	15%	43%
Middle East & North Africa	1303	45%	16%	39%
South Asia	1242	47%	14%	39%
Sub-Saharan Africa	1996	41%	32%	27%
	Exports			
	Total	Inland	Ports	Other
East Asia & Pacific	459	22%	32%	46%
Europe & Central Asia	1759	59%	10%	31%
High income: OECD	872	48%	26%	26%
Latin America & Caribbean	1044	42%	17%	41%
Middle East & North Africa	973	44%	16%	40%
South Asia	922	46%	13%	41%
Sub-Saharan Africa	1587	47%	22%	32%

Source: World Bank Doing Business Data, 2007 and author's calculations

Table 2-4: Ocean and Inland Freight (US$/TEU) 2005

	Total Freight Rate	Inland Freight		International Freight	
Exporter		Rate	Share %	Rate	Share %
China	1409	395	28	1014	72
India	3488	1284	37	2204	63
Indonesia	1633	685	42	949	58
Japan	2148	857	40	1291	60
Malaysia	1284	434	34	850	66
Korea	1855	1049	57	806	43
Thailand	1751	1047	60	705	40

Source: De (2008)

Table 3-1 Liner Rates on Major Trade Routes

period	oil	Asia/US EB	US/Asia WB	Eur/Asia EB	Asia/Eur WB	US/Eur EB	Eur/US WB	Simple Average
1Q 98	16.0	1345	1119	1040	1183	1472	1284	1241
2Q 98	14.7	1459	1015	869	1227	1477	1210	1210
3Q 98	14.2	1561	999	873	1353	1397	1221	1234
4Q 98	12.9	1614	842	807	1465	1308	1188	1204
1Q 99	13.1	1619	832	716	1512	1165	1100	1157
2Q 99	17.7	2018	871	723	1525	1111	1045	1216
3Q 99	21.7	2203	818	730	1568	1040	1054	1236
4Q 99	24.6	2188	736	776	1612	1031	1127	1245
1Q 00	28.8	2125	751	664	1594	939	1148	1204
2Q 00	28.8	1953	852	710	1597	958	1198	1211
3Q 00	31.6	2041	939	793	1673	1022	1264	1289
4Q 00	32.0	1932	867	797	1618	987	1255	1243
1Q 01	28.8	1874	877	826	1566	938	1290	1229
2Q 01	27.9	1765	869	760	1468	943	1236	1174
3Q 01	26.7	1624	801	688	1296	890	1253	1092
4Q 01	20.4	1605	720	663	1154	899	1223	1044
1Q 02	21.7	1594	812	601	1073	912	1189	1030
2Q 02	26.2	1469	807	646	1105	862	1156	1008
3Q 02	28.3	1479	812	694	1208	865	1191	1042
4Q 02	28.2	1502	773	721	1287	774	1176	1039
1Q 03	34.1	1493	794	706	1397	771	1212	1062
2Q 03	29.0	1687	832	755	1543	774	1341	1155
3Q 03	30.2	1979	839	773	1653	778	1395	1236
4Q 03	31.2	1892	810	754	1662	795	1432	1224
1Q 04	35.2	1850	802	733	1686	778	1437	1214
2Q 04	38.4	1863	819	731	1738	788	1425	1227
3Q 04	43.9	1946	838	735	1826	810	1436	1265
4Q 04	48.3	1923	806	769	1838	829	1471	1273
1Q 05	49.7	1867	800	801	1795	886	1544	1282
2Q 05	53.1	1845	781	821	1794	906	1655	1300
3Q 05	63.2	1906	815	815	1778	935	1725	1329
4Q 05	60.0	1878	825	825	1709	1009	1815	1344
1Q 06	63.3	1836	815	793	1454	995	1829	1287
2Q 06	70.4	1753	828	804	1408	1010	1829	1272
3Q 06	70.4	1715	839	806	1494	1041	1954	1308
4Q 06	60.0	1671	777	792	1545	1066	1762	1269
1Q 07	58.1	1643	737	755	1549	1032	1692	1235
2Q 07	65.0	1675	765	744	1658	1067	1653	1260
3Q 07	75.5	1707	780	777	1952	1115	1725	1343
4Q 07	90.8	1707	794	905	2054	1147	1766	1396
1Q 08	97.9	1725	861	968	2021	1193	1700	1411
2Q 08	124.0	1837	999	1061	1899	1326	1652	1462

Table 4-1
Value of Time Saving and Share in World Trade for Selected Products

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

Note: Categories correspond to Standard Industrial Trade Classification System (SITC) two-digit categories. Selected categories have been further disaggregated for purposes of illustration.

Table 4-2
Per-day Tariff Equivalents, by Region

Region	Imports	Exports
High income: OECD	0.8	1.0
East Asia and Pacific	0.8	0.7
Europe and Central Asia	0.9	0.7
Latin America and Caribbean	0.9	0.8
Middle East & North Africa	1.0	0.4
Sub-Saharan Africa	0.9	0.9
South Asia	1.5	0.6

Table 4-3 -- Time Sensitivity of Asian Trade

	Air Share in Exports to US		Per Day Time Sensitivity	
	1995	2005	Imports	Exports
China	10.6	23.3	0.69	0.77
Indonesia	8.3	14.0	1.00	0.56
India	47.1	41.4	1.50	0.76
Kyrgyz Republic	1.6	12.9	1.22	5.92
Malaysia	48.2	71.6	0.87	0.62
Phillipines	44.8	48.0	0.65	0.51
Thailand	29.4	41.3	0.87	0.84
Hong Kong	41.4	38.5	0.74	0.81
Japan	27.8	25.6	0.57	1.14
Korea	48.2	34.2	0.58	1.03
Singapore	78.2	79.0	0.75	0.82
Taiwan	31.1	37.1	0.69	0.91

Source:
1. COMTRADE, US Imports of Merchandise, author's calculations
2. Per day time costs based on Hummels 2007 "Time as a Trade Barrier"

Table 4-4
Tariff Equivalents vs. Applied Tariffs, by Region (all values are percent ad-valorem)

Region	Per-Day	Inland Transport	Customs	Port	Total	Applied Tariff
IMPORTS						
High income: OECD	0.8	1.3	1.2	2.1	4.6	2.7
East Asia and Pacific	0.8	1.5	3.3	2.1	6.9	5.6
Europe and Central Asia	0.9	6.3	4.0	2.6	12.8	4.7
Latin America and Caribbean	0.9	2.1	3.1	3.7	8.9	7.0
Middle East and North Africa	1.0	4.4	5.4	5.9	15.6	10.0
Sub-Saharan Africa	0.9	8.3	8.4	9.0	25.6	11.2
South Asia	1.5	13.0	6.7	9.4	29.1	25.5
EXPORTS						
High income: OECD	1.0	2.0	1.8	1.1	4.5	4.5
East Asia and Pacific	0.7	1.1	1.7	1.0	3.8	5.2
Europe and Central Asia	0.7	2.7	3.9	2.0	8.4	2.8
Latin America and Caribbean	0.8	2.2	2.8	2.2	7.1	3.9
Middle East and North Africa	0.4	1.2	3.2	1.2	5.5	2.7
Sub-Saharan Africa	0.9	5.3	7.7	4.0	16.8	4.1
South Asia	0.6	3.2	4.0	2.2	9.5	6.5

Table 4-5 Relative Importance of Inputs, Traded Goods

	1975	1985	1990	1995	2000	Total % Change
(A) Unit Input Usages of Imported Intermediates (IT/GO, %)						
China	--	1.5	1.7	2.8	3.3	120.5
Indonesia	3.2	3.1	3.2	3.8	4.1	29.8
Japan	2.0	2.2	1.9	2.0	2.4	19.6
Korea	8.5	7.8	7.3	7.6	8.7	2.3
Malaysia	4.2	9.1	10.0	16.0	24.7	486.1
Taiwan		6.7	9.3	12.5	15.2	126.2
Philippines	4.0	4.6	6.4	8.0	16.0	303.1
Singapore	16.3	26.2	28.1	28.3	24.5	50.3
Thailand	3.1	5.1	10.9	12.0	13.7	339.3
U.S.	0.7	1.1	1.2	1.8	2.2	229.9
(B) Input Share of Trade (IT/TT, %)						
China	--	36.1	61.7	62.3	65.2	80.8
Indonesia	38.8	51.2	38.7	45.6	49.7	27.9
Japan	71.8	61.1	51.7	47.3	43.6	-39.3
Korea	67.2	69.7	67.4	64.0	71.1	5.8
Malaysia	36.9	46.0	36.2	45.3	71.4	93.4
Taiwan		69.1	64.6	63.1	63.3	-8.5
Philippines	41.5	66.6	47.4	46.2	63.1	52.1
Singapore	54.2	62.4	53.8	59.7	61.8	14.1
Thailand	45.3	45.7	53.6	56.7	67.9	49.9
U.S.	43.3	29.8	24.7	31.2	33.9	-21.6
(C) Exported Inputs in Total Exports (%)						
China	--	64.9	52.1	44.6	36.7	-43.4
Indonesia	86.9	94.1	81.6	70.3	71.3	-18.0
Japan	53.5	36.8	42.5	51.1	55.0	2.8
Korea	47.2	41.6	39.8	61.6	64.7	37.0
Malaysia	69.6	86.7	73.4	63.0	62.1	-10.8
Taiwan	--	35.2	42.6	54.5	67.4	91.4
Philippines	83.6	64.0	48.7	55.6	66.0	-21.0
Singapore	49.2	52.2	48.0	50.7	66.9	35.9
Thailand	74.2	62.9	43.1	49.1	55.4	-25.4
U.S.	70.6	66.7	61.3	58.9	61.5	-12.8

Table 4-6 Decomposing Mexican Export Growth to US 1991-2004

	Mexican Exports to US					Rest of World Exports to US	
	Exports (In billions)	Number HS 6 products	Mean value per shipment (In thousands)	Number HS 10 products	Mean value per shipment (In thousands)	Number HS 6 Products	Number HS 10 Products
1991	36.1	2887	12510	5821	6204	4991	14731
1992	39.3	2901	13536	5873	6686	4984	14741
1993	43.8	3017	14502	6122	7147	4989	14845
1994	53.8	3129	17206	6772	7950	4984	15325
1995	67.0	3414	19612	7684	8714	4994	15759
1996	79.0	3591	21987	8369	9434	5089	16007
1997	88.9	3641	24424	8864	10032	5088	16527
1998	96.1	3635	26449	8606	11172	5092	16287
1999	111.2	3671	30297	8706	12775	5094	16311
2000	134.7	3647	36944	8736	15423	5093	16371
2001	127.5	3588	35542	8595	14837	5096	16345
2002	128.8	3640	35378	8735	14743	5185	16759
2003	129.6	3604	35965	8639	15004	5183	16783
2004	142.6	3627	39328	8737	16326	5178	16771
Log percentage change							
1991-2004	1.374	0.228	1.145	0.406	0.968	0.037	0.130
1991-1996	0.782	0.218	0.564	0.363	0.419	0.019	0.083
1996-2004	0.591	0.010	0.581	0.043	0.548	0.017	0.047

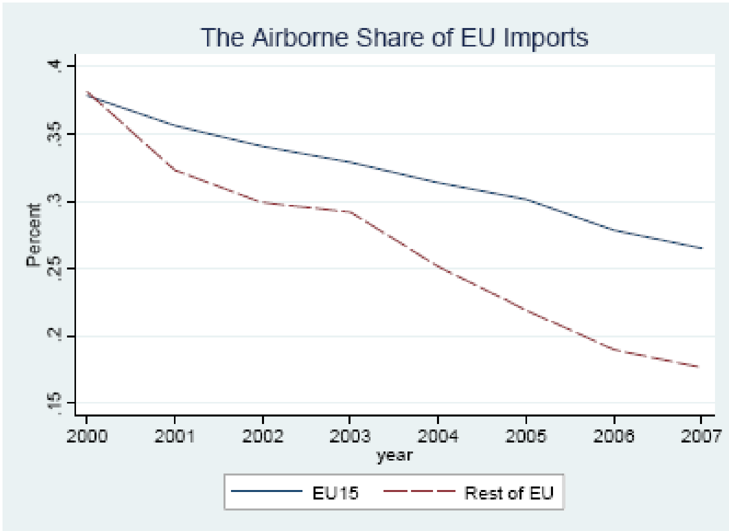
Table 4-7 -- Decomposing Asian Trade Growth 1995-2005

	Log Change in Export				
			Shipment Value		
	Value	Number of shipments	Mean	Median	90th pctile
China	1.43	0.80	0.63	-0.09	0.38
Indonesia	0.46	0.65	-0.19	-0.91	-0.47
India	0.99	0.80	0.19	-0.32	-0.02
Kyrgyz Republic	0.26	0.61	-0.35	-1.84	-1.25
Malaysia	0.46	0.42	0.03	-0.12	-0.04
Phillipines	0.53	0.35	0.18	-0.65	-0.43
Thailand	0.46	0.51	-0.04	-0.85	-0.24
Hong Kong	0.33	0.04	0.29	-0.61	-0.14
Japan	0.07	-0.06	0.13	-0.18	0.01
Korea	0.62	0.29	0.33	-0.33	-0.05
Singapore	0.45	0.10	0.35	-0.29	0.07
Taiwan	0.27	0.10	0.17	-0.37	-0.12

	Log Change in Import				
			Shipment Value		
	Value	Number of shipments	Mean	Median	90th pctile
China	1.42	0.39	1.03	-0.27	0.44
Indonesia	0.19	0.19	-0.01	-0.57	-0.38
India	1.27	0.64	0.63	-0.45	0.09
Kyrgyz Republic	0.55	1.81	-1.26	-2.35	-1.66
Malaysia	0.22	0.12	0.10	-0.29	-0.07
Phillipines	0.12	0.09	0.03	-0.56	-0.49
Thailand	0.34	0.34	0.00	-0.85	-0.38
Hong Kong	0.24	0.11	0.13	-0.63	-0.35
Japan	0.24	0.12	0.12	-0.37	-0.13
Korea	0.46	0.30	0.16	-0.70	-0.23
Singapore	0.27	0.11	0.16	-0.58	-0.22
Taiwan	0.34	0.13	0.20	-0.62	-0.19

Notes:
1. Source: COMTRADE database, authors calculations
2. First year of Phillipines data is 1996. First year of Taiwan data is 1997.

Figure 1-1


The Airborne Share of EU Imports
Percent
.15
.2
.25
.3
.35
.4
2000
2001
2002
2003
2004
2005
2006
2007
year
EU15
Rest of EU

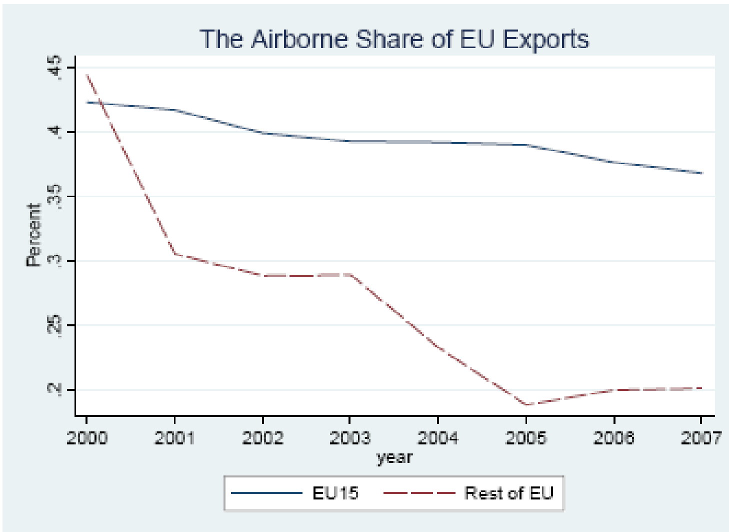

The Airborne Share of EU Exports
Percent
.2
.25
.3
.35
.4
.45
2000
2001
2002
2003
2004
2005
2006
2007
year
EU15
Rest of EU

Figure 2-1

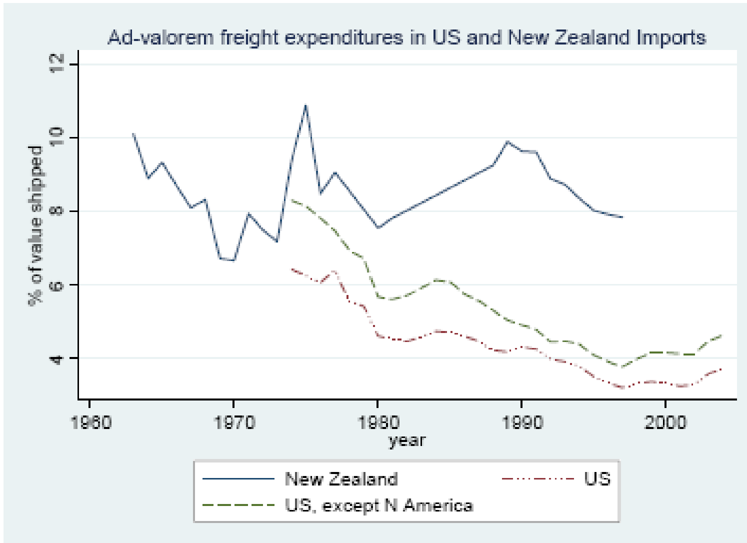
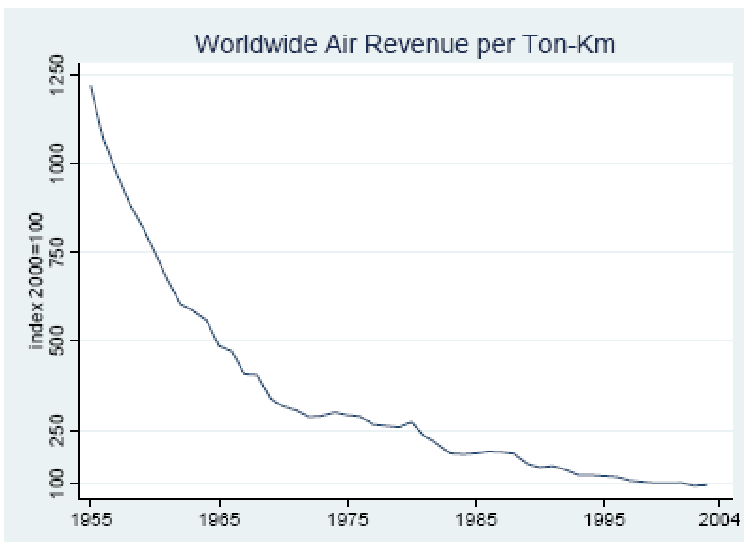
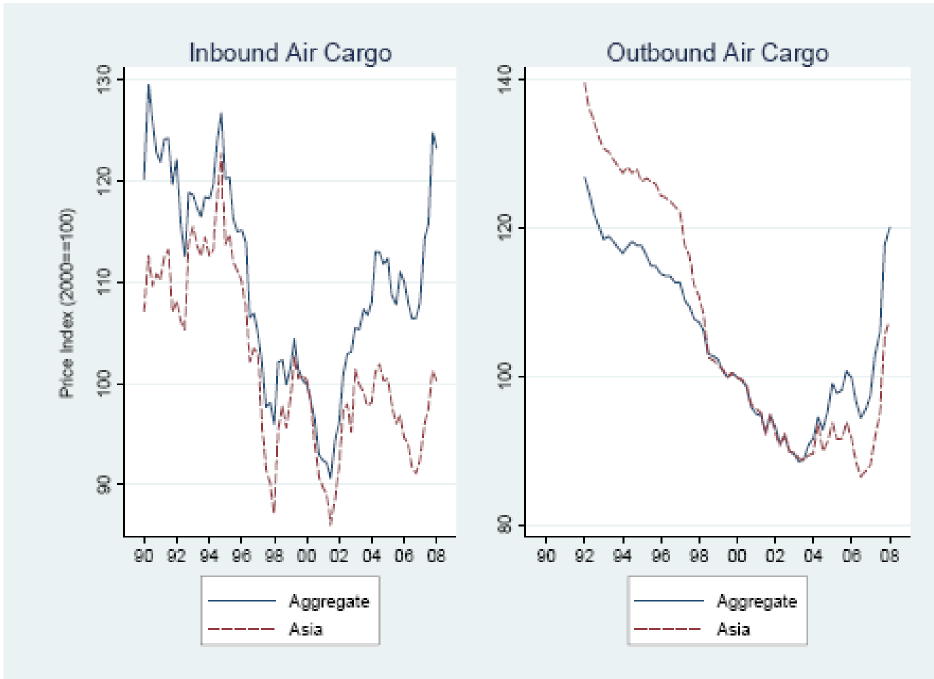


Figure 2-2



Source, IATA World Air Transport Statistics, authors calculations

Figure 2-3 US Air Cargo Price Indices



source: Bureau of Labor Statistics

Figure 2-4

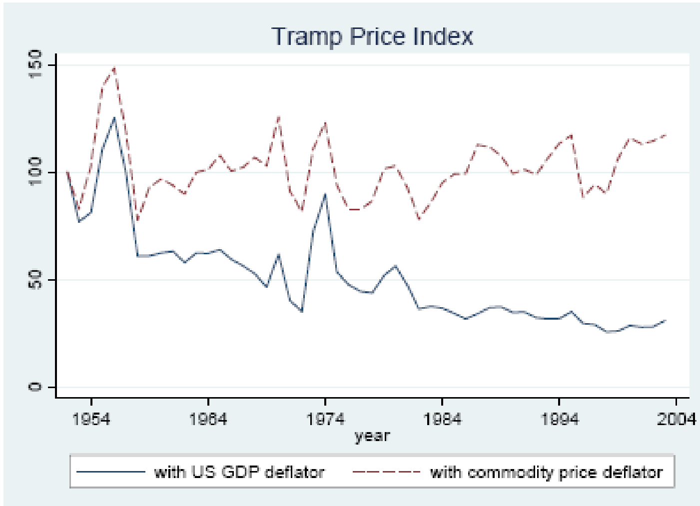


Figure 2-5

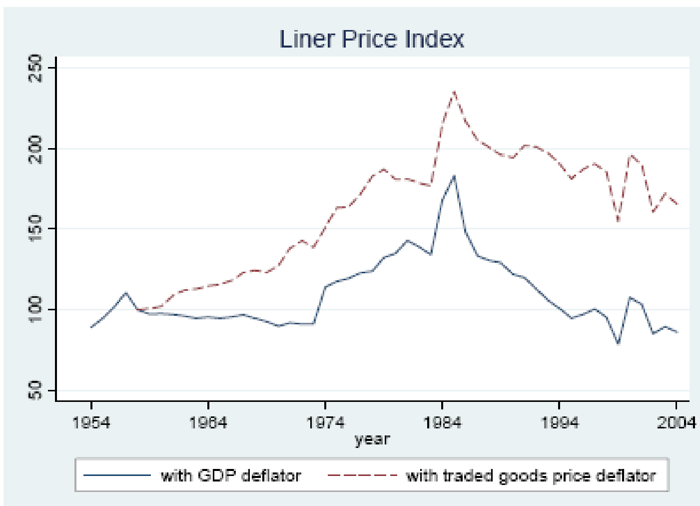


Figure 2-6

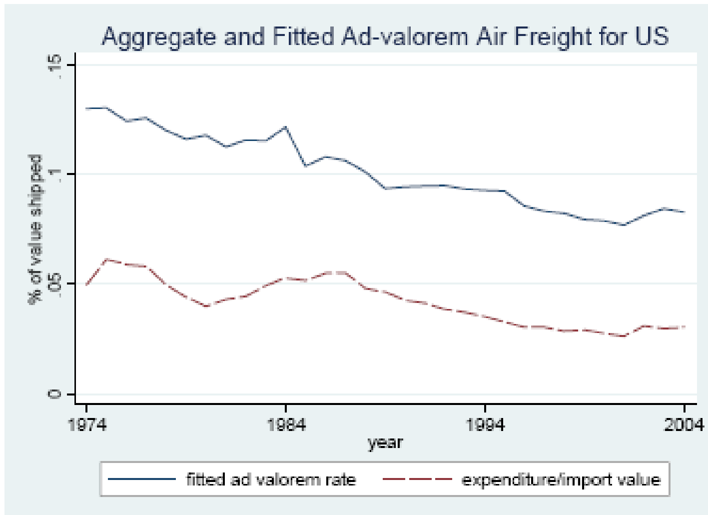
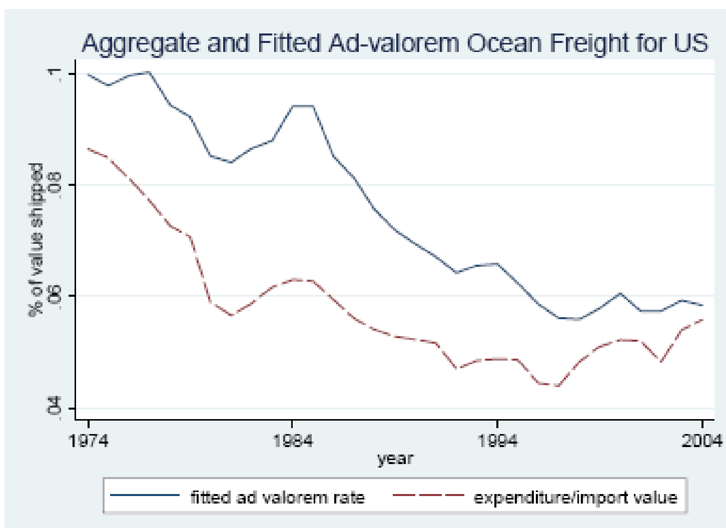
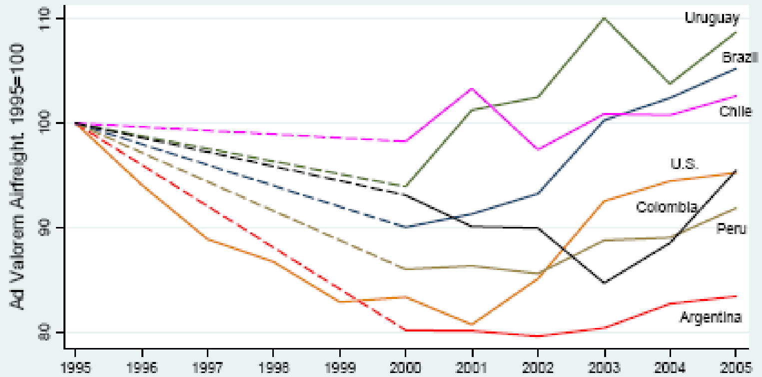


Figure 2-7



Figures 2-8 & 2-9

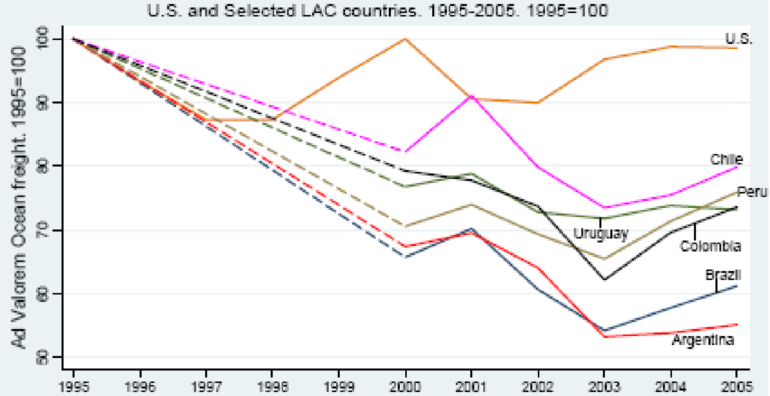
Figure 8-Trend in Import Airfreight after Controlling for Changes in Trade Composition.
U.S. and Selected LAC countries. 1995-2005. 1995=100



Note: Airfreight is freight plus insurance as a share of imports. It was estimated by regressing ad-valorem freight on the weigh-to-value ratio of the goods imported and on year and partner-good fixed effects. Data for LAC countries is only available for 1995 and 2000-2005. See text for details.

Data source: ALADI and U.S. Census Bureau

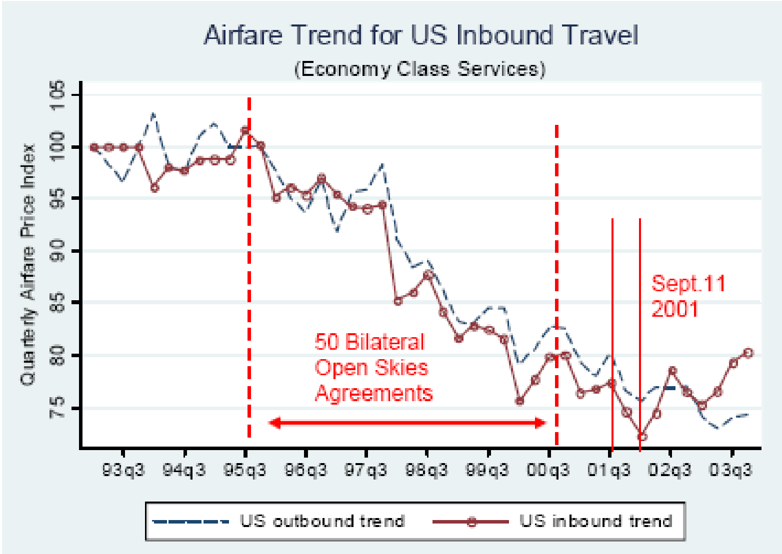
Figure 9-Trend in Import Ocean freight after Controlling for Changes in Trade Composition.
U.S. and Selected LAC countries. 1995-2005. 1995=100



Note: Ocean freight is freight plus insurance as a share of imports. It was estimated by regressing ad-valorem freight on the weigh-to-value ratio of the goods imported and on year and partner-good fixed effects. Data for LAC countries is only available for 1995 and 2000-2005. See text for details.

Data source: ALADI and U.S. Census Bureau

Figure 3-1


Airfare Trend for US Inbound Travel
(Economy Class Services)
Quarterly Airfare Price Index
105
100
95
90
85
80
75
93q3
94q3
95q3
96q3
97q3
98q3
99q3
00q3
01q3
02q3
03q3
50 Bilateral
Open Skies
Agreements
Sept.11
2001
US outbound trend
US inbound trend

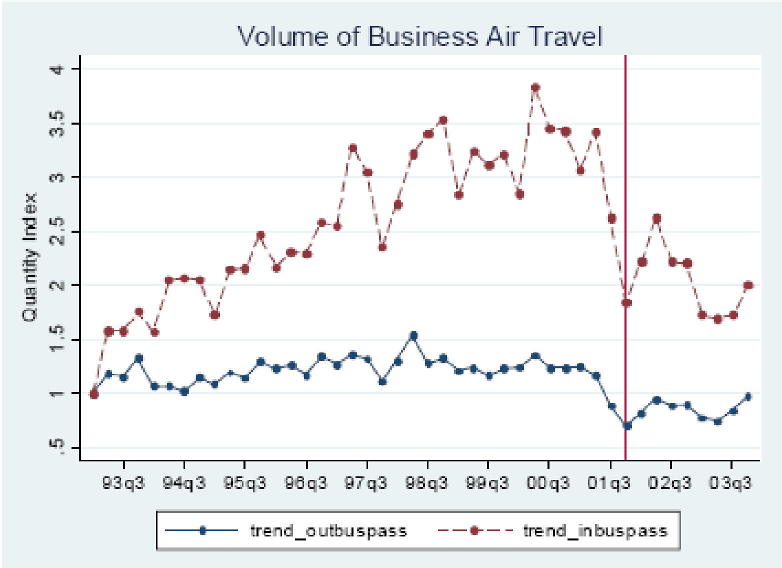
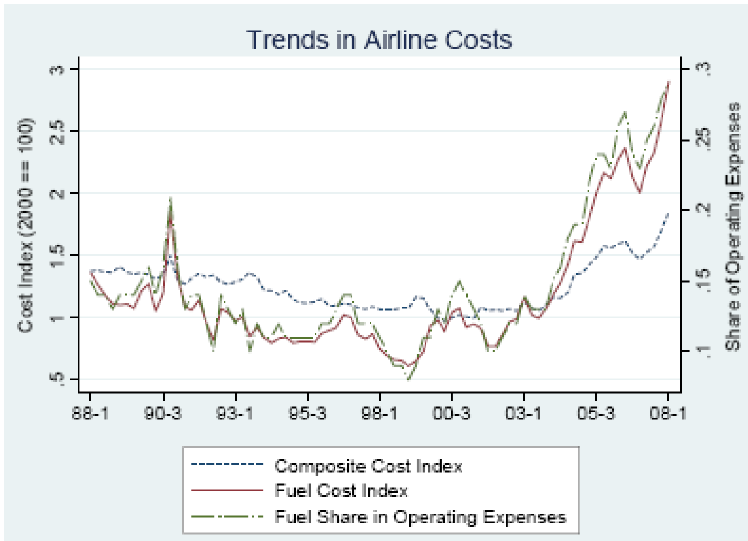

Volume of Business Air Travel
Quantity Index
4
3.5
3
2.5
2
1.5
1
.5
93q3
94q3
95q3
96q3
97q3
98q3
99q3
00q3
01q3
02q3
03q3
trend_outbuspass
trend_inbuspass

Figure 3-2



source: data from Air Transport Association

Figure 3-3

Figure 4-1 The Weight/Value of EU Trade, by EU Country

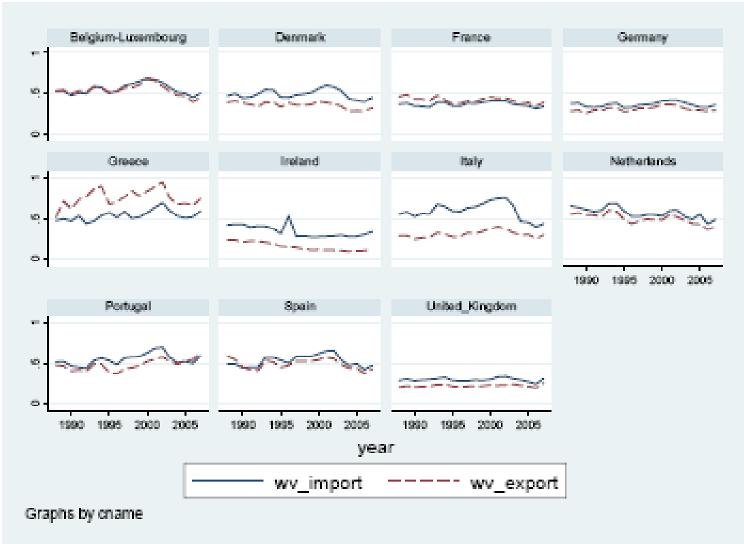


Figure 4-2 Weight/Value for EU Trade -- by Partner

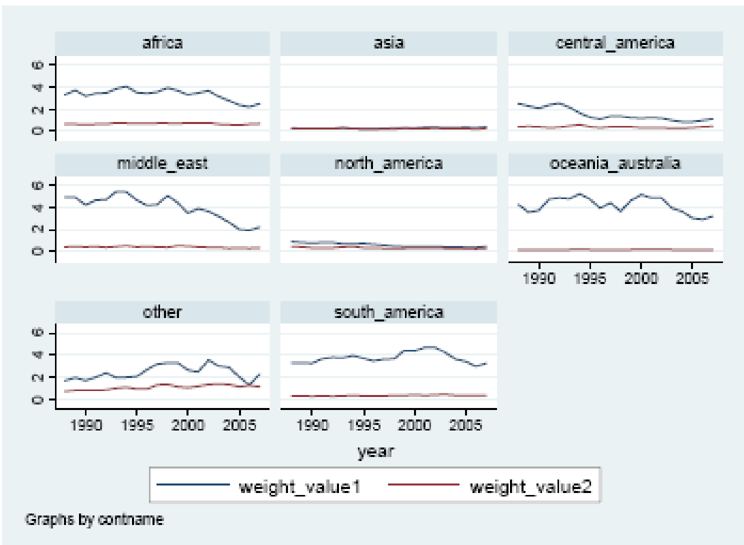


Figure 4.3. **Weight/Value of Trade 1995-2005**