Have International Transportation Costs Declined?

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Abstract:

While the precise causes of post-war trade growth are not well understood, declines in transport costs top the lists of usual suspects. However, there is remarkably little systematic evidence documenting the decline. This paper provides a detailed accounting of the time-series pattern of shipping costs. Direct evidence from an eclectic mix of data shows that ocean freight rates have increased while air freight rates have declined rapidly. Indirect evidence suggests that the cost of overland transport has declined relative to ocean transport. For all modes, the freight costs associated with increased distance have declined. Data on the changing composition of trade are broadly consistent with these changes in relative prices.

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I. Introduction

Have international transportation costs declined? Several papers by Harley (1980, 1988, 1989) and North **(**1958, 1968**)** provide evidence of substantial reductions in shipping costs from 1850-1913, a period in which world trade grew rapidly. The post-war era has also been characterized by rapid trade growth, and while the precise causes of that growth are not well understood, declines in transport costs top the lists of usual suspects.[1] Unlike the earlier period, however, there is remarkably little systematic evidence documenting the decline.[2] This paper provides a detailed accounting of the time-series pattern of shipping costs. In addition, it offers insights into how changes in the nature of transportation have affected the composition of trade.

A better understanding of international integration, its causes and consequences, requires the careful measurement of trade barriers. The level of barriers has implications for a broad range of questions, from the welfare consequences of trade growth[3], to the extent of product and factor price equalization, the effect of trade on domestic competition, and the diffusion of technology embodied in goods, among others. Further, relative changes in barriers of different types may alter the composition of trade, or provide incentives to shift to other forms of integration. For example, declines in the cost of air relative to ocean transport may greatly facilitate trade in time-sensitive goods. Similarly, if the cost of moving goods remains high while the cost of moving information *about* goods declines, firms may find direct investment more efficient than trade for serving foreign markets.

The term "transport cost" in popular use subsumes shipping expenses but is also used loosely as a catch-all for any number of important costs that impede trade. This paper focuses on shipping costs rather than a broader basket of component costs for three reasons. One, measurement must start somewhere and it is sensible to begin in obvious places. Two, changes in shipping costs can be directly interpreted in terms of their effect on trade -- all trade

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[1] See Krugman (1995). Recent papers by Rose (1991), Baier and Bergstrand (1998) and Djankov, Evenett, and Yeung (1998) have attempted to attribute trade growth to changes in tariffs, transport costs as measured by IMF cif/fob ratios, and other causal factors.

[2] An exception is Lundgren (1996), who relies on a very small number of goods and routes to conclude that the constant dollar price of shipping a ton of bulk commodities fell substantially between 1950 and 1993. However, as shown in section II of the current paper, the ad-valorem barrier posed by shipping has *not* fallen for bulk commodities, and a considerably broader set of data reveals a general pattern of shipping cost increases.

[3] Small reductions in trade barriers yield large trade volume increases (and little additional gain from trade) if foreign and domestic goods are sufficiently close substitutes in production or consumption. See Yi (1999) and Hummels, Ishii and Yi (1999) for more on this point.

necessarily requires shipping and the ad-valorem equivalent of the barrier is simple to calculate. In contrast, we know that the cost of moving information has declined orders of magnitude but not how this relates to trade. (What fraction of costs do international telephone calls represent for the average exporter?) Three, papers that have directly investigated the relative importance of shipping versus tariff barriers in the cross-section have consistently identified shipping costs as the more important barrier.[4] This evidence, which covers many countries and several decades, suggests that a careful accounting of time-series change in trade barriers as a whole must include a careful accounting of time-series change in shipping costs.

Unfortunately, there is no single source of data that provides a definitive picture of the costs of transport. One source with great breadth of coverage, matched partner reports of trade flows available from the IMF, has been used by a number of authors use to assess transportation costs across countries and over time.[5] In principle, exporting countries report trade flows exclusive of freight and insurance (fob), and importing countries report flows inclusive of freight and insurance (cif). Comparing the valuation of the same aggregate flow reported by both the importer and exporter yields a difference equal to transport costs. The time series derived from IMF sources accords well with conventional wisdom -- transportation costs have declined steadily while trade has grown (see Table A1). However these data are subject to two serious problems. First, as an appendix details, the IMF data are of extremely low quality, and rely on extensive imputation. Second, as aggregate data they are subject to compositional effects that mask the true time series in transport costs. Shifts in the types of goods traded, or the sets of partners with whom a country trades, will affect measured costs even if the unit cost of shipping remains unchanged. These compositional effects are likely to be quite important – trade in cheaply shipped manufactured goods has grown much more rapidly than bulky and expensively shipped agricultural and mining products.

Sections 2, 3, and 4 gather together an eclectic mix of data on the costs of transportation. Sources include: index numbers for ocean shipping prices gathered from shipping trade journals; air freight prices constructed from survey data on air cargo; and freight expenditures on imports

[4] Waters (1970) and Finger and Yeats (1976) employ US import data from the mid 1960s. Sampson and Yeats (1977), and Conlon (1982) employ Australian import and export data from the early 1970s. All find that transport costs pose a barrier similar in size, or larger than tariffs. Further, several of these demonstrate that the rate of effective protection posed by transport costs is extremely large. Hummels (1999) employs data from seven countries in 1994, including the US, New Zealand, and five Latin American nations. He again finds a larger barrier posed by transport, and finds an especially large role for these costs in determining bilateral variation in trade.

collected by customs agencies in the United States and New Zealand. Index numbers on ocean shipping indicate that the unit cost of transport (price per ton) for charter shipping bulk commodities has fallen since 1952, but the ad-valorem equivalent of the barrier (or, price per dollar of commodities shipped) has risen. For general or liner cargo, including containerized vessels, shipping costs have risen steadily whether measured per quantity or per value shipped. Several reasons for the differences between charter and liner cargo series are discussed. One important difference is that tramp shipping prices do not include port costs, which rose sharply in the period during which the series diverge. This suggests that, inclusive of port charges, the cost of tramp shipping services may have risen as well.

Survey data on air cargo indicates steady cost declines, with the largest changes occurring on routes involving the US. These data also indicate a sizeable reduction in the distance premium for air shipping. That is, the cost of air shipping on lengthy routes has fallen relative to short routes. The relative movements in air versus ocean shipping prices provide a plausible explanation for the rapid growth of air transport, with the largest growth again occurring in US trade.

Customs data for New Zealand show that aggregate ad-valorem freight expenditures have fluctuated, but not declined over the last 30 years. US customs data for 1974-1996 show declining ad-valorem freight expenditures, but this can be attributed to two factors. First, the initial year of data corresponds to a global maximum in all other measured shipping price series. Second, compositional shifts toward lower transport-intensity goods have pulled down aggregate expenditures. Analysis of detailed shipments data shows a declining distance premium similar to that found in air cargo data. Finally, indirect evidence on overland shipping for the US suggests strong substitution toward land-based rather than ocean-based transport.

II. Ocean Freight Rates

I begin this section with a brief discussion of ocean transport and important changes that have occurred in the post-war era, then report index numbers for ocean shipping prices and supporting cost data. The dry cargo ocean transport market consists primarily of tramps for shipping large quantities of bulk commodities (primarily, iron ore, grain, coal, bauxite/alumina

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[5] See footnote 1. Harrigan () uses a similar methodology employing OECD trade data.

and phosphate) and liner shipping for general (that is, all but large quantity bulk) cargoes.[6] Roughly two-thirds to three-quarters of world trade by value is moved via liners.[7]

Tramp shipping services include voyage and time charters, with prices set in spot markets.[8] A voyage charter is a contract to ship a large quantity of a dry bulk commodity between specific ports, using part or all of one or more vessels. Rates are generally quoted as US$ per ton and may include some minimal loading and/or unloading expenses.[9] A time charter is a contract to employ the services of an entire ship for a set period of time (usually up to a year). Weekly rates are quoted in terms of US$ per dead-weight tonnage of the ship, and do not include loading and unloading expenses. Liners ply a fixed trade route in accordance with a predetermined time table and are organized into cartels, or conferences, that fix shipping prices for a year or more at a time. Pricing formulas differ substantially across goods, with prices fixed variously in weight, bulk, and/or value terms. Adjustments and surcharges are occasionally made to compensate for unexpectedly high oil prices or port charges, or to offset currency fluctuations.[10]

Ocean shipping has undergone several technological and institutional changes in the post-war era. The first important change is the growth of containerization for general cargo shipping. In 1966, the first container ships with international service appeared on North Atlantic routes, with North America-Asia and Europe-Asia routes appearing 2 and 3 years later. In 1970, container ships comprised only 2 percent of the world shipping tonnage available to carry general cargoes. By 1996, that total had grown to nearly a third, with tonnage carried equal to 55 percent of general cargo trade.[11] Growth on US trade routes occurred much earlier, with 40

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[6] To this one could add specialized bulk carriers and tankers for shipping oil and some other liquids. These are omitted from the discussion in this section because of their highly specialized nature, and because available data are quite limited.

[7] Careful calculations reported in the US Federal Maritime Commission, *MARAD*, various years, reveal that the liner share of US non-tanker trade in 1956,66,76, and 89 was 83, 68, 66, and 74 percent respectively. Noisier estimates for 1970 put world-wide liner trade at 60 percent (Lawrence, International Sea Transport) to 66 percent (OECD, *Maritime Transport*). However, liner shipping is responsible for perhaps 20 percent of trade by weight.

[8] Tramp shipping is organized through the Baltic Freight Exchange, an information clearing house that matches demanders and suppliers of bulk shipping services. The exchange also offers thinly traded futures contracts on shipping services.

[9] The norms for which port services are covered varies with particular commodities and routes, but the extent of these services is small relative to those covered by liner shipping.

[10] As rates are fixed in US dollars, a depreciation of the dollar represents a decline in the foreign currency price of shipping. When facing a large dollar depreciation, conferences levy a surcharge to keep the foreign currency price roughly constant.

[11] Source: UNCTAD, *Review of Maritime Transport*, various issues. The ship classification "general cargo" excludes bulk cargo carriers and oil tankers..

percent of trade with Europe and Asia containerized in 1970, and 55 percent of trade over all routes containerized by 1979.[12]

Containerized cargo is thought to be an important source of improved shipping efficiency, and early estimates predicted that containerization would yield transport savings as high as 50-60 percent relative to conventional cargo ships.[13] A 1970 UNCTAD study cited substantial reductions in stevedoring (port labor) costs and ship's time in port, increases in ship speed and cargo holding capacity per ship ton, and greatly facilitated inland movement of goods between transport modes.[14] Various estimates place conventional (non-container) ships' time in port at one-half to two-thirds of the ship's life. Lengthy port times trump cost savings that might be achieved through investments in larger and faster ships – large ships are more expensive to dock, and increased speed is of no value when ships are in port. The UNCTAD study estimated port time reductions for containerships of up to 60 percent, and this makes additional savings through size and speed investments possible. However, these improvements come at the expense of higher capital and fuel costs, and data presented below show that these early estimates appear to be substantially overstated.

A second change is the growth of open registry shipping, in which ships are registered under flags of convenience in order to circumvent costs associated with regulations and unions in wealthier countries. Open registry fleets comprised 5 percent of world shipping tonnage in 1950, 25 percent in 1980, and 45 percent in 1995.[15] Tolofari (1989) uses 1984 survey data to estimate that open registry operating costs are from 12 to 27 percent lower than traditional registry fleets for bulk carriers, and 18 to 27 percent lower for tankers, with most of the estimated savings coming from manning expenses.[16]

Have these technological and institutional changes resulted in lower shipping prices? To answer this, I provide index numbers for unit prices ($/quantity) of ocean-borne shipping. Price

[12] Data are from *MARAD, Containerized Cargo Statistics*, and *Maritime Transport*, various years. The discrepancy between tonnage available world-wide and tonnage carried for US trade may reflect differences between US and world intensity of container use, or simply reflect containerships higher speeds and greater storage capacity per ship tonnage.

[13] UNCTAD, Unitization of Cargo, showed savings estimates as high as 60 percent, with estimates depending critically on capacity utilization, and reduced stevedoring costs. A 1967 McKinsey study predicting savings of 50 percent.

[14] UNCTAD, Unitization of Cargo.

[15] OECD, *Maritime Transport*, various years.

[16] The range depends on ship size, with open registry savings per ton shipped being smaller for large ships (for which manning expenses are a smaller portion of total costs).

indices for ocean shipping are available from several sources, with varying coverage of time periods, goods shipped, and routes. Details on these indices and their construction are provided in an appendix and summarized here.

Two of the indices cover worldwide tramp shipping prices for voyage and time charters, respectively, and are constructed by the *Norwegian Shipping News* (later, *Shipping News International*).[17] The voyage charter price index represents a weighted bundle of spot market prices ($/ton) for shipping major bulk commodities on several important routes world-wide. The time charter index reports a weighted bundle of spot charter prices for ships of various sizes ($/tonnage) in many ports world-wide. A third index, calculated by the German Ministry of Transport, measures liner shipping prices and the coverage differs from the other series in a few important respects. The index heavily emphasizes general cargo, rather than bulk commodities. It thus includes containerized shipping and manufactured merchandise of all sorts, and so is more representative of the majority of world trade. Also, the index includes only those liners loading and unloading in Germany and Netherlands, rather than offering world-wide coverage. Finally, unlike tramp shipping, liner prices include port costs and charges.

The nominal values for the price indices are reported in Table A1 of the appendix. To evaluate the real costs of shipping over time, I deflate the indices and graph them in Figures 1 and 2. I use the US GDP deflator to provide a constant dollar value for the unit price of tramp shipping a given quantity of merchandise. (Tramp prices are quoted in US$ so this is an appropriate benchmark currency.) Of course, countries experiencing a real appreciation (depreciation) relative to the dollar will enjoy lower (higher) shipping prices. The liner index reflects DM liner rates, and so I deflate these with the German GDP deflator.

I also deflate each series by a relevant import or export price series. This yields the price of shipping a bundle of goods relative to the price of that bundle, a measure that is similar in spirit to the ad-valorem barrier posed by shipping.[18] I deflate both tramp shipping price series using an index of bulk commodity prices, constructed using the same goods and weights as used

[17] Several other shipping organizations construct indices. The NSN indices are chosen as they cover the longest time period. However, the indices constructed by various organizations exhibit a high degree of correlation.
[18] This will be a relatively crude approximation when different weighting schemes are used for the indices top and bottom. Also, the level of the barrier is not meaningful and so it is appropriate to look only at the change in freight prices.

in the voyage charter index. [19] The time charter index is based a bundle of ship sizes, and not on cargo type, and so it is not possible to construct a directly appropriate goods price series. However, time and voyage charters are generally employed to ship the same bulk commodities, so it is reasonable to employ the same goods price series. Finally, as the liner index captures primarily German trade in a broad range of goods, I deflate this series using an aggregate traded goods price index for Germany.[20] For comparison, I convert the DM price of shipping to US$ at the current exchange rate and deflate this series using an aggregate traded goods price for the US.

Figure 1 display time series plots for time and voyage charters. Leaving aside very large price spikes in the oil shock years, and in the 1954-1957 period,[21] both series exhibit downward trends in prices relative to the US GDP deflator. This suggests that the real price of bulk shipping, measured in dollars per ton, has declined over time.[22] However, the series are flat or even increasing for long periods – time chartering costs actually trend up between 1960 and 1980. Also, time charter rates return by 1989 to 1960 levels, and other price series indicate that the 1989 increase was sustained throughout the 1990s.[23] This indicates forty years of fluctuating, but not declining, real prices. For many purposes such as measuring the limiting effect of shipping on trade, the ad-valorem equivalent of the barrier is the relevant measure. The second panel of Figure 1 reveals that, compared to the commodity price deflator, voyage charter rates are roughly constant and time charter rates are increasing. That is, the price of bulk commodities has fallen faster than the unit cost of tramp shipping, yielding no change or even increases in the barrier to trade posed by international transport.

These intriguing results warrant three caveats. First, there are the usual issues with index numbers, the weighting scheme employed and revisions to it. This does not appear to be a major problem. Several other series covering tramp shipping, but employing somewhat different

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[19] All commodity price series, including aggregated import and export price indices, are taken from IMF, *International Financial Statistics*.

[20] The liner price series includes both imports and exports so I employ a simple average of the aggregate import and export price series.

[21] According to UNCTAD's *RMT*, the 1955-1957 spike was due initially to extremely (and unexpectedly) large US grain exports to Europe. In 1956, the closure of the Suez canal caused a re-routing of ships around the Cape of Africa that led to large price increases on Asia-Europe routes.

[22] While smaller in magnitude, this finding is similar to Lundgren (1996), who uses a small set of goods and routes to document declines in the (real) dollar per ton price of bulk shipping.

[23] The *NSN/ISN* series stops reporting in 1989. The Baltic Freight Index, reported in the appendix, begins in 1985 and covers similar shipping prices. It shows a roughly constant level from 1989-1997.

commodities, routes, weighting schemes and with weights updated in different years, are highly correlated with the index reported here.[24] Second, the precise time series pattern of the ad-valorem barrier depends on the import prices chosen for comparison. The indices cover a relatively small set of commodities, including many that have seen sizeable real declines in price over this period. The results in the second graph may be reversed for goods that have experienced real price increases.[25]

Third and most importantly, the indices cover what are essentially spot markets for shipping, and so the observed prices may not be generally reflective of transportation costs. Tramp shipping markets and especially time charters exhibit highly volatile prices. This is not surprising – the demand for particular vessels in particular ports at a particular point in time varies considerably, and short-run supply may be highly inelastic. While someone is clearly paying the spot price (or else its unobserved), it may not be allocative for all or even most shippers. Alternatives include owning, rather than contracting for, shipping, or the use of futures contracts on shipping services. Thus it may be unwise to examine month to month, or even year to year variation in the series as an indicator of true shipping costs. However, assuming an elastic long run supply curve, longer time spans may be informative about general trends in shipping costs.

Some comfort can be found in noting that similar patterns are found for liner shipments of bulk commodities. Ad-valorem liner rates for a small number of specific commodities and routes dating back to 1961 have been collected by the Royal Netherlands Shipowners Association and reported in UNCTAD, *Review of Maritime Transport*, various years. These are reported in Table 1, along with their price per ton equivalents.[26] In this small sample of goods, liner shipping prices per ton for this small sample have fallen. Ad-valorem rates have fluctuated considerably, but have not declined.[27]

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[24] See appendix for other series. A notable series published by the UK Chamber of Shipping has a correlation of .9 with the NSN series reported here.

[25] Lundgren (1996) reports declines in the cost of shipping bulk commodities that are even larger in ad-valorem than in quantity (shipping price per ton) terms. This cannot be right, as the commodities in question have experienced real price declines of 50-80 percent over the relevant period.

[26] The data are converted to price per ton using series on commodity prices.

[27] One would like to do a calculation similar to Table 1 for a broad range of goods and routes. It is possible to obtain extremely detailed data on liner shipping rates for individual shipments from the microfiche archives of the US Federal Maritime Commission. However, there are enormous data collection and concordance difficulties that must be overcome in order to construct a usable time series for even very small numbers of goods and routes.

The volatility of tramp prices raises a final interesting point about this market. Spot prices implicitly include shipping costs as well as the costs associated with getting the market to clear over vessels, ports, and time. That is, uncertainty about demand results in price volatility if ships are not properly allocated when and where they are needed. Separating shipping costs from information costs is difficult, but there is one interesting clue. For the series reported here, monthly data are much more volatile than yearly data, but this volatility has significantly decreased over time.[28] This suggests that the market has become more efficient at allocating vessel supply, and the lower volatility may also result in lower average prices for the charter market.[29] However, while costs associated with uncertain demand may be important for tramps, they are not broadly relevant for the liner trade or when producers own their own ships. That is, an important source of cost savings in this market is unlikely to be found in other markets.

Figure 2 reports movement in the liner shipping price index relative to the German GDP deflator, and US and German traded goods prices. Regardless of deflator employed, the price of shipping rises precipitously, with especially rapid increases through the 1970s. Relative to German prices, liner rates peak in 1985 then decline. Relative to US prices, rates peak in 1979 and in 1987, and stay high thereafter. (The difference simply reflects movements in the real exchange rate.) If containerization and the associated productivity gains lead to lower shipping prices, this should show up primarily in the liner series. Yet liner prices exhibit considerable increases relative to tramp prices.

Again, caveats are warranted. The main concern is whether the liner prices for German shipping are broadly informative about shipping costs generally. This is especially problematic if liner conference cartels have the ability to successfully price discriminate. Optimal price discrimination on German routes may not resemble optimal discrimination elsewhere. Further, if firms can avail themselves of a shipping option outside the cartels, they may avoid the cartels' monopoly pricing. To address this concern, I provide some specific though limited data on non-German liner rates as well as cost data for shipping. These additional measures demonstrate that the price increases shown here are general.

The especially rapid liner price increases that occur in the 1970s for German trade appear to have occurred more broadly. Throughout the 1970s, the *Review of Maritime Transport*

[28] Volatility is measured as the standard deviation of within-year monthly prices, normalized by the yearly average.
[29] This would be the case if risk averse shippers charge a premium to supply into the spot market.

reported in some detail the tariff increases (and surcharges of various kinds) levied by shipping conferences. Annual increases of 10-15 percent were common across nearly all routes.[30] Studies of rates on US North Atlantic liner routes find increases ranging from 61 to 103.5 percent between 1971 and 1975, even larger than those found in German trade.[31] Lastly, changes in liner shipping prices per quantity from Table 1 are highly correlated with the liner index, and in particular, these prices rise dramatically in real terms during the 1970s.

Data on operating costs show similar increases and also illustrate important differences between tramp and liner shipping and their price indices. Prior to the oil shocks, shipbuilders constructed very large, fast containerships with double or triple the fuel consumption per unit of transport capacity of conventional liners. When oil prices more than quadrupled in 1974, vessel operating costs for these ships rose dramatically, as much as 86 percent in one estimate.[32] Note that vessel operating costs are a much small fraction of total costs for liners than for tramps. This explains the sharp tramp price increases in oil shock years in contrast with the muted response of liner prices.

Capital costs also increased substantially. Shipbuilding costs for conventional cargo liners rose 161 percent between 1971 and 1977, and building costs for containerships rose over 300 percent. Meanwhile, the cost of containers themselves **(**a substantial portion of capital costs**)** rose 126 percent over this period.[33] In short, increases in capital and operating costs, while high fleet-wide, were especially severe for the containerships that constituted a growing fraction of liner trades in this period.

Finally, among the most common increases in liner rates were surcharges related to rising port costs. A 1977 UNCTAD study 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.[34] The port charge data provide a useful contrast between the liner and tramp

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[30] Indeed, the "problem" of liner rate increases was sufficiently severe that several national agencies and the UN commissioned studies to determine whether the price increases were warranted by cost considerations or merely represented increased rents accruing to the cartels.

[31] Sletmo and Williams (1981).

[32] Sletmo and Williams (1981), based on proprietary operating and cost data from North Atlantic conference liners with container fleets. They found that the ratio of fuel costs to all other vessel operating costs rose from .4 to 1.6.

[33] *Fairplay International Shipping Weekly* and Sletmo and Williams (1981). The latter reports that differences in construction technique – more intensive use of steel and labor in containerships – led to the differential price increases.

[34] UNCTAD, "Port Problems: causes of increases in port costs and their impact", 1977. The study cited rapidly rising labor costs, large capital investments that did not appear fully compensated by productivity increases, and overinvestment combined with average cost pricing in the absence of competition.

shipping price series. Recall that, apart from the oil shocks, tramp shipping prices were roughly constant through the 1970s. However port charges for tramps are generally borne by the persons shipping goods, not the shipowners, and so are not generally included in published prices.[35] The UNCTAD study found port charges for bulk commodities more than doubling between 1965 and 1976, and increasing as much as 250 percent from 1962-1976.[36] This suggests that the price of tramp shipping inclusive of these charges may have increased substantially throughout the 1970s.[37]

In summary, liner price indices for German trade exhibit substantial increases over time and this evidence is supported by (admittedly, less systematic) cost data and liner price data from other routes. Tramp shipping prices have been constant or rising when measured in ad-valorem terms, and decreasing when measured in price per ton terms. However, tramp prices omit port charges, and may therefore have increased over time.

III. Air Cargo Rates

In this section I report data on the cost of international air transport. One of the most important post-war changes in international transport has been the growth in air freight. Table 3 expresses world-wide growth in air cargo from 1951 to 1994 in terms of ton-kilometers performed. Annualized growth rates exceed 10 percent over this period, and international cargo has grown from a third of all cargo flown to nearly 84 percent. US data show that the value share of trade moved via air freight increased only slightly from 1965 to 1980 (7.3 to 10.6 percent of US imports plus exports), but grew rapidly thereafter, with 25 percent of trade in 1996.[38] However, it should be noted that air transport is concentrated in relatively few places. In 1997, tonnage moved on international routes including North America (primarily the US)

[35] That is, port charges are borne by the persons shipping goods, not shipowners.
[36] UNCTAD, “Port Problems”. These data are taken only from Rotterdam, but this is one of the major developed country ports.
[37] However, it is unlikely that tramp shipping increased at the same rate as liner shipping. Several of the cost increases were most severe for liners. In addition, the liner versus nonliner share of US trade declined steadily throughout the 1970s, before rebounding when liner prices began to drop.
[38] Source: US Census, and Statistical Abstract of the United States, various years. Note that the share of air transport in exports is much higher than in imports for the US. This reflects differences in composition between the two, as US exports are much lighter per unit of value than US imports.

constituted 40 percent of all international movements. North American international and domestic air shipments comprise 53 percent of the world total.[39]

Cost data for air transport are more sparsely reported than for ocean transport. I rely on two sources. The first is the *World Air Transport Statistics (WATS)*, which reports world-wide air freight revenue and ton-kilometers performed each year from 1955-1997. The second is "Survey of International Air Transport Fares and Rates", published annually by the International Civil Aviation Organization (ICAO) between 1973 and 1993. These surveys cover air cargo freight rates (price per kg for shipment between two cities) for air travel markets around the world. While the underlying data are not available, the surveys contain rich overviews of the data that are sufficient for constructing a time series on air cargo costs. Specifically, the *Survey* provides information on mean fares and distance traveled for many regions as well as simple regression evidence to characterize the fare structure. The reported regressions estimate the elasticity of freight rates with respect to distance for each regional route group in each year. For most routes and years, distance shipped explains a large portion of the variation in cargo fares, so rates constructed from the regression will be reasonably informative.[40]

Annualized growth rates for air freight revenues (totals, and revenues relative to ton-kilometers and tons shipped) constructed from *WATS* are reported in Table 4. The data reveal rapidly growing revenues from 1955-1980, then a significant slowdown through the 1980s prior to renewed growth in the 1990s. Average revenues per ton-km decline in every period, with especially rapid decreases of 8-9 percent per annum until 1970, and somewhat slower rates of decline thereafter. This series can be thought of as a crude measure of price per output unit. However, the simple average may overstate the true decline in costs. Suppose the cost technology for air shipping is given by

$$C = a_t (ton)(km)^b$$

where a_t is a time-specific cost shifter. If the elasticity of costs with respect to distance shipped is less than one, doubling distance shipped results in a decline in average costs per ton-miles.

[39] IATA, *World Air Transport Statistics*.
[40] Regression R2 of 0.8 to 0.9 are common.

WATS data indicates a rapid rise in mean distance shipped over time, so a useful measure of the cost of shipping requires an estimate of the relevant elasticity.

There are two sources one might use. The first comes from the ICAO *Survey*, which reports regressions of (log) cargo rate on the (log) air distance between cities world-wide.[41] Using world-wide data, the elasticity of costs per kg with respect to distance is .81 in the earliest available year, 1973. A second source is US trade data, detailed in the next section. Estimates for 1974 indicate that the elasticity of costs per kg with respect to distance is 0.5.[42] I use these estimates to construct changes in average revenues correcting for the rise in distance shipped. This calculation reveals somewhat slower rates of decline compared to the simple average rate.[43]

The ICAO *Survey* provides a more detailed source of data on air cargo rates, albeit a much shorter time series. The regression evidence reported there can be used to evaluate changes in the level of air freight rates, as well as changes in the structure of rates over time. To examine changes in the level of rates I construct, for each year and route group, a predicted cargo rate (dollars per kg) for the mean distance shipment in that route group.[44] I deflate this series using the US GDP deflator, and an index of air-shipped traded goods prices. The latter is used in place of a more general import price series for two reasons. One, the time series of prices in air-shipped goods may differ substantially from the overall import series. Two, the series can be constructed in a way that allows a precise calculation of changes in the ad-valorem freight rates.

To explain, air freight rates are quoted in dollars per kg shipped, so multiplying the rate by the weight-value ratio of a good immediately yields the ad-valorem rate. The question then becomes: what is an appropriate weight-value ratio to employ? The aggregate weight-value ratio is greatly influenced by movements in bulk commodity prices that are never air shipped and so are not relevant for this calculation. (For US import data, the aggregate weight-value ratio (all goods) yields ad-valorem rates in excess of 750 percent.) Simply using the weight-value ratio for air-shipped goods is also problematic because it will understate cost declines. If air prices decline relative to ocean air, shipment by air becomes feasible for heavier goods. This raises the observed weight-value ratio. To deal with both problems, I construct a Laspeyres type index

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[41] The rate is the price per kilogram for shipping a package up

[42] The much lower distance elasticity from US trade data matches ICAO estimates for route groups involving the US.

[43] Of course, this assumes a constant elasticity over time as well as ignoring compositional effects (where air transport has grown and whether costs have fallen at different rates in those regions).

using US trade data in 1973.[45] The price per observation (country j, commodity k) is measured in dollars per kg, where all shipments are included regardless of transport mode. The quantity weights are given by the air-shipped share of an observation *jk* in all air-shipped trade for that year. This yields a measurement of movement in weight-value for predominantly air-shipped goods that does not suffer from endogenous compositional shifts in the basket as prices move. Note that the same price series is applied to data from all routes – actual ad-valorem rates vary across routes due to differences in their traded goods basket.

In Table 5, I report annualized rates of change in air freight rates for each route group between 1973 and 1993. The first column reports changes in the constant dollar price per kg for air shipping. Pooling data from all routes, prices decrease 1.53 percent annually, with decreases reflected in all individual routes except those involving Central America. The extent of price declines varies substantially over routes, with longer routes and those involving North America showing the largest drops. Changes in ad-valorem rates are reported in the second column, and these are much larger than price per kg freight rates. The difference can be explained by substantial real increases in the price of predominantly air shipped goods.[46] However, most of the declines are concentrated in the 1973-1980 period, with much smaller rates of change thereafter. The timing of the rate reduction lies in sharp contrast to the *WATS* data, which show small declines in the 1970s and larger declines in the 1980s. Given the extremely rapid growth in air transport during the 1970s shown in Table 3, one is inclined to discount the crude *WATS* numbers in favor of the *ICAO* data.

Finally, the ICAO *Survey* data can also be used to examine changes over time in the structure of airfares. I construct a distance premium for each route group by calculating the predicted airfare (dollars per kg) for shipments equal to twice and one-half the mean distance shipped for that route group. The ratio of these rates is the distance premium and I report annualized rates of change in the last column of Table 5. These data reveal that while airfares are falling at all distances they are falling especially quickly for very long routes.

[44] For comparability across years, a common mean distance shipped is used within each route group over time. This is constructed as the over time average of the yearly mean distances for that route group.

[45] Trade by transport mode at this level of detail are only available from US sources and so these must be applied to all routes in place of country specific deflators.

[46] Since the same air-shipped import price index is applied to all route groups, conclusions about in changes across routes are identical to the series using shipping price per kg.

The evidence on air cargo rates provides a marked contrast to the data on ocean shipping. Aggregate data reveal extremely large declines in costs between 1955 and 1997, while more detailed survey data reveals smaller, though still substantial, declines from 1973-1993. Changes in these relative prices provide a highly plausible explanation for the shift toward air transport shown in Table 2.

IV. Trade Data: US and New Zealand Customs Reports

In this section I use freight data gathered from United States and New Zealand customs reports.[47] In each case, customs authorities report the value of trade inclusive (cif) and exclusive (fob) of shipping costs. These data have the following advantages. First, they provide a reliable time series on freight expenditures that can easily be expressed in ad-valorem equivalent terms. Second, the data allow me to decompose changes in aggregate freight rates into changes in unit shipping costs and changes in shipping characteristics, including commodity composition, exporter composition, and goods prices.

The US data come originally from the US Census Bureau, “US Imports of Merchandise” and cover years 1974-1996. Importers are required to report the cif and fob valuation of imports, the quantity and weight of the good, and duties paid. Census also reports the country of export, a highly disaggregated goods classification (TSUSA or in later years, Harmonized System) shipping mode (sea, land, air), and district of entry and unlading. The New Zealand data are derived from import shipment data. For years 1965-1986, the publication “New Zealand Imports” reports cif and fob values of trade at the 2 digit SITC level, aggregated over all exporting countries, as well as cif and fob values for each exporter, aggregated over all goods. For years 1988-1997, electronic data sources available from Statistics New Zealand provide shipment weight and cif and fob trade values by exporting country at the 5-digit SITC level.

Figure 3 reports time series variation in aggregate ad-valorem freight rates for the US and New Zealand. The US data exhibit declining rates (from 6.4 to 3.6 percent of import value), while the New Zealand data fluctuate (between 7 and 11 percent of import value) but show no clear trend. Of course, these aggregate expenditure data are subject to important compositional effects. The composition hypothesis can be simply illuminated by decomposing the aggregate expenditure on freight rates. Let transportability vary over goods, exporters, and time, represented by a unique ad-valorem freight rate for each, f_{jkt}, and denote the value of trade in that observation as V_{jkt}. The aggregate ad-valorem freight rate in each period is given by a weighted average of commodity x country transportation costs, with weights given by the value share of each good in trade, $S_{jk} = \frac{V_{jk}}{\sum_{jk} V_{jk}}$, or $f_t = \frac{\sum_{jk} V_{jkt} f_{jkt}}{\sum_{jk} V_{jkt}} = \sum_{jk} S_{jkt} f_{jkt}$

This effect can be shown simply in cross-section by comparing the trade-weighted average freight rate to a simple average rate (i.e. setting shares equal to 1/n for all observations). Unweighted mean freight rates for the US range between 12 and 15 percent ad-valorem, or roughly two to three times the weighted rates. Similarly, if trade growth has occurred primarily in cheaply-shipped commodity groups, this will cause a decline in the aggregate ad-valorem rate. Consider the following simple characterization of shipping costs. Denote P_s as the unit cost of shipping ($/ton), Q_k as the quantity shipped in units, w_k as the weight per unit, and P_k as the unit price of the good. The freight expenditure F on good k equals the total weight shipped multiplied by the unit shipping cost. Expressing this as a fraction of the good's value, we have the ad-valorem freight rate, which is increasing in the unit weight-value ratio for the good.

(1) $$f_k = \frac{F_k}{V_k} = \frac{P_s Q_k w_k}{P_k Q_k} = P_s \frac{w_k}{P_k}$$

The top half of Table 6 shows the composition of world-wide trade growth from 1950-1995, with index numbers representing quantities of total trade and three broad aggregates: agricultural products, mining products, and manufactures.[48] Trade in manufactured goods has grown much more rapidly (27-fold) than either agriculture (5-fold) or mining (7-fold) products. The bottom half of the table shows US imports (1969-1995), split into one-digit SITC categories. It reports the value share of each category in total trade and two measures of transportability –

[47] A broader set of countries would be highly desirable but these are the only countries whose public use trade data includes a lengthy time series on shipping costs.

the aggregate weight-to-value ratio and aggregate expenditures on freight relative to value in each category. Easily transported manufactures (SITC 5-9) grow while expensively shipped commodities (SITC 0-4) shrink.

An estimate of true shipping prices must then separate price effects from compositional effects. Given the limited detail in the New Zealand data from 1964-86 (freight rates by country, or freight rates by 2-digit SITC commodity), it is only possible to control for composition using a standard index number approach. I employ Laspeyres and Pasche price indices, where the observation price is the ad-valorem freight rate for that country (commodity), with weights equal to the country (commodity) value share in trade for base years 1964 and 1997, respectively. This holds fixed the country (commodity) share of trade and allows only prices (freight rates) to vary.

The bottom half of Figure 3 displays price indices for New Zealand compared to the aggregate freight rate with price indices set equal to the freight rate in base years. Both indices track the aggregate freight rate closely, departing only in the years furthest from the base. In each case, the departures tend to flatten the series – the Pasche index pulls initial rates down, and the Laspeyres index pulls rates up in later years. A price index that holds country composition constant shows even smaller departures from the trade-weighted average rate.

The US data allow a more detailed exploration of freight rates and their variation over time. In particular, I use detailed information on shipment characteristics in order to extract a time series on shipping costs controlling for compositional effects. The model of ad-valorem freight rates for shipments originating in country j, terminating at port p, in commodity k at time t is given by

(2) $$\ln f_{jkpt} = \ln DIST_{jp} + \ln \frac{w_{jkpt}}{p_{jkpt}} + h_k + T_t + T_t^2 + (T_t \cdot \ln DIST_{pj}) + (T_t^2 \cdot \ln DIST_{pj})$$

The regression controls for distance shipped and weight-value, and allows time-invariant differences across goods in shipping costs. A linear and a quadratic trend, along with trend interactions with distance are included to capture changes in shipping prices. Results are very

[48] These rates refer to growth in the quantity of trade in each category (arrived at by dividing unit values by unit prices). Measuring growth in the value of trade, manufacturing trade grew 100-fold while agriculture and mining trade grew 15 and 50-fold, respectively. Data are gathered from WTO sources.

similar when year and year*distance interactions are employed. Good k refers to a 5-digit SITC commodity, and the time period spans 1974-1996.

Table 7 reports results of equation 2. The controls enter as expected, with freight rates rising with weight/value and with distance. Also, the distance and weight/value coefficients are higher for air transport. This, sensibly, suggests that shipping any particular good from any particular exporter will be more expensive via air. More interesting are the trend variables, which reveal an increasing intercept, but a declining distance elasticity over time. This indicates a kind of rotation in the freight-distance profile – freight rates are rising over short distances, and falling over long distances. For air cargo, this reproduces the result found in the ICAO *Survey* data. For ocean shipping there is a ready technological explanation for the phenomenon – large, fast containerships provide the greatest cost savings over long routes. A falling distance coefficient may represent the steadily growing use of containerships in trade.

To evaluate the overall trend in freight rates, I evaluate the regression at the variable means. At the mean distance shipped, both ocean and air freight rates fell about 60% between 1974 and 1996. However, the US Census Bureau only began collecting freight expenditure data in 1974 and this is an especially inauspicious beginning year. The New Zealand data and the tramp shipping indices indicate that shipping prices peaked in this year, and 1973-1974 also represents the single largest year to year change in the liner shipping index. If these trends are also present for US trade, the first year of the data corresponds to a local maximum in the price series, making it difficult to draw broad conclusions about the longer time series.

A few crude calculations drawing on the longer series are possible. For ocean freight, the New Zealand data, the liner and both tramp indices all show freight rate increases of around 30 percent from 1973-1974. For air freight, ICAO *Survey* data indicate an average increase of about 8.5 percent between 1973-74 for routes involving the US. I impute ocean and air freight levels for 1973 by lowering the 1974 levels 30 and 8.5 percent respectively. Compared to the 1973 level, ocean freight prices increase sharply until 1976, then decline steadily. However, they do not reach the 1973 levels again until 1990. This yields a series that is broadly consistent with the other ocean freight prices shown thus far -- prices fluctuate until the late 1980s, then decline over the last decade. Compared to the 1973 level, air freight prices briefly increase, but drop below 1973 levels in 1977, and drop 50 percent by 1996.

V. Inland Transport: Indirect Measures

Data on the costs of inland transport are extremely difficult to obtain, except on a case study basis. The few available studies typically find inland transport charges to be the largest portion of international shipping expenses. For example a 1968 OECD study finds sea freight for liner cargoes, including loading and unloading charges, to be between 40 and 60 percent of total door to door shipping charges. Combining this with estimates that loading and unloading costs equal as much as half of sea freight charges for liner cargoes, one arrives at a value of only 20 to 30 percent for purely ocean transport. Clearly then, one would like some assessment of the costs of overland transport.

Two pieces of indirect evidence are available. Liner freight rates include costs of inland transport related to port costs, while the other series (tramp shipping, customs trade data) do not. Liner rates have increased relative to the other series, and this relative movement may reveal, crudely, increases in port costs.

Second, one can indirectly evaluate changes in overland versus ocean shipping prices by observing changes in relative use of these modes. The US is a large land mass with four potential entry coasts (Pacific, Atlantic, Gulf, Great Lakes). A European shipper needing to send goods to California then has several options: place the goods on a very long ocean voyage through the Panama Canal, or enter the goods on the Atlantic or Gulf Coast and land-ship them to California. Presumably this decision depends on the relative costs of ocean versus inland journeys. Is there any evidence that shippers substitute away from ocean-intensive shipping toward land-intensive shipping?

To measure this, I calculate for each shipment the entry port that would minimize ocean shipping distance and compare this to the actual port used. The ratio of the two provides a measure of "excess ocean distance".[49] Especially interesting are cases where a shipper's minimum ocean distance port is on an entirely different coast than the port actually employed. Figure 4 plots excess distance over time for those shipments where the minimum distance and entry ports are on different coasts. It shows a marked decline in excess distance, that is, a shortening of ocean voyage legs in favor of longer land distance legs. This is especially striking as estimates from the previous section indicate that the distance costs of ocean transport are falling over time, making excess distance shipped progressively cheaper.

Of course, a demonstration that inland transportation costs have fallen is not necessarily an indication that international costs have fallen relative to domestic costs. Domestic transactions may use domestic transport more intensively than international transactions because domestic transport is but one component in the overall international transport chain. This would imply that the costs of international transactions costs actually rise in relative terms when domestic costs drop. However, domestic transactions have the option to locate internally so as to minimize these costs, and so may less intensively demand domestic transport.

V. Implications and Extensions

This paper has drawn on an eclectic mix of data to show that the cost of ocean transport has risen and the cost of air transport has fallen over time. Further, changes in rate structures indicate a decline in the costs of distant relative to proximate transport. Both changes match compositional shifts in trade toward air shipping and toward distant partners.

Two challenges remain. First, the data provided here implicitly assume that transportation services are of homogeneous quality over time, and this will likely concern many readers. Undoubtedly there have been important technological changes in shipping, but the difficulty lies in identifying which of these provide improved transport services to importers, and are not already being measured. More efficient ships ought to yield lower shipping prices; navigational aids that limit accidents should show up in reduced insurance premiums. Further, it should be noted that the replacement rate for shipping is very slow; new ships are added at a rate of approximately 2% of the existing fleet each year, and the average age of the active fleet is 15 years old. Thus, even dramatic technological improvements require decades to be felt fleet-wide. It also suggests that whatever improvements have occurred, they are not so great as to obsolete the existing capital stock.

Perhaps the most obvious quality improvement is speed. This is manifest in the switch to air transport as well as in substantially increased ship speed for ocean liners. A simple-minded

[49] Young (1999) performs excess distance calculations for international transit shipping and demonstrates that goods take very indirect routes. The same appears to be true even for single country shipping.

view of the value of time might focus primarily on inventory-holding costs, and these are likely to be quite small. (A transatlantic crossing at top fleet speeds today might save a week relative to top fleet speeds four decades ago.) A broader view would focus on why particular goods are time intensive, and the possibility that faster transport might open up trade in entirely new goods or lead to entirely new organizations of production. An obvious example is perishable foods, a more compelling example is trade in intermediate components intended for just-in-time linkage into a multi-country vertical production chain.

This leads to the second challenge, identifying the role that transportation, narrowly defined, plays in trade growth and international integration more broadly. One is tempted to look at the evidence on ocean freight rates and conclude that transport costs cannot plausibly lead to trade growth since they have not declined! But again, this is too simple. It may be that compositional changes in the price of transport -- relative reductions in air, overland, and distance premia -- can tell us a great deal about how trade has grown. They may similarly tell us much This paper provides simple, suggestive correlations. Careful study is required.

Finally, it may simply be that changes in transportation, narrowly defined, do not much affect trade growth or international integration. The third challenge then, is to identify trade barriers, or components of transportation broadly defined, that do matter. This paper is a first step in that process.

References

Baier, Scott, and Bergstrand Jeffrey (1998) "The Growth of World Trade: Tariffs, Transportation Costs, and Intermediate Goods", mimeo, U. Notre Dame

Conlon, R.M. (1982), "Transport Cost and Tariff Protection of Australian Manufacturing", *Economic Record*, 73-81.

Evenett, Simon, Djankov, Simeon, and Bernard Yeung (1998) "The Willingness to Pay for Tariff Liberalization", mimeo, University of Michigan.

Finger, J.M. and Yeats, Alexander (1976), "Effective Protection by Transportation Costs and Tariffs: A Comparison of Magnitudes", *Quarterly Journal of Economics*, 169-176.

Harley, C. Knick, (1980) "Transportation, the World Wheat Trade, and the Kuznets Cycle, 1850-1913", *Explorations in Economic History*, 17, 218-250.

Harley, C. Knick, (1988) "Ocean Freight Rates and Productivity, 1740-1913: The Primacy of Mechanical Invention Reaffirmed", *Journal of Economic History*, 48, 851-876.

Harley, C. Knick, (1989) "Coal Exports and British Shipping, 1850-1913", *Explorations in Economic History*, 26, 311-338.

Hummels, David (1999), "Toward a Geography of Trade Costs", mimeo, University of Chicago

Hummels, David, Ishii, Jun, and Kei-Mu Yi, (1999) "The Nature and Growth of Vertical Specialization in International Trade", mimeo, University of Chicago

Krugman, Paul, (1995), "Growing World Trade: Causes and Consequences", *Brookings Papers.*

McKinsey and Co., (1967)"Containerization: the Key to Low Cost Transport"

OECD, *Maritime Transport*

OECD (1968) *Ocean Freight Rates as part of Total Transport Costs*

Sampson, G.P. and Yeats, A.J. (1977), "Tariff and Transport Barriers Facing Australian Exports" Journal of Transport Economics and Policy, 141-154.

Sletmo and Williams (1981) <u>Liner Conferences in the Container Age.</u>

Rose, Andrew (1991), "Why Has Trade Grown Faster than Income?" *Canadian Journal of Economics*, Vol 24.

Tolofari (1986), <u>Open Registry Shipping</u>

UNCTAD, *Review of Maritime Transport*

Waters, W.G. (1970), "Transport Costs, Tariffs, and the Patterns of Industrial Protection, *American Economic Review*, 1013-20.

Yeats, Alexander (1978) "On the Accuracy of Partner Country Trade Statistics" Oxford Bulletin of Economics and Statistics, vol 40, no. 4.

Appendix I: Data

Shipping Indices

All data on shipping indices were collected from various issues of UNCTAD, "Review of Maritime Transport" and various issues of OECD, " Maritime Transport". These publications collected the data from the sources noted below. For details on the precise construction of the indices see UNCTAD, "Level and structure of freight rates, conferences practices and adequacy of shipping services" or the original sources.

Norwegian shipping indices (tramp time charter and tramp voyage charter) are compiled by the Norwegian Shipping News, later, Shipping News International. The tramp time charter index for Norway reports an index of the cost of employing entire vessels for a period of time less than nine months. Coverage is worldwide, and the use of the ships (i.e. which goods they will transport) is ignored. The index includes vessels of varying size and speed. The weighting used for various ship classes was originally based on 1947, and was updated to a new base year in 1967 (base year 1965) and again in 1972 (base year 1971).

The voyage charter index for Norway is a weighted index number of the cost of shipping a given quantity of goods. The basket includes bulk commodities such as grains, coal, sugar iron ore, phophate, scrap iron, rice, fertilizers and copra, with each commodity represented with several shipping routes. The prices for a specific commodity are averaged across routes, and the commodity basket is constructed using weights for each commodity. Weights originally used a 1947 base year, updated in 1967 to a 1965 base year.

The liner shipping index for Germany is compiled by the German Ministry of Transport. It differs from other series in three important respects. First, it covers prices charged by liner conferences, not prices prevailing in spot shipping markets. Second, its covers only those ships loading and unloading in Germany and Netherlands. (The Netherlands is included as a significant fraction of German imports land in the Netherlands and are transported into Germany via inland freight.) Third, it covers both dry bulk and general cargo, the latter of which includes containerized shipping and merchandise of all sorts. The weighting of the index (both commodities within dry bulk and general cargo and dry bulk v. general cargo) was based on

1954, and updated in 1968, 1985, 1990, and 1996 to include base years of 1965, 1980, 1985, and 1991, respectively.

All of the series are updated to new base years for weighting schemes. To provide continuity of the series, old and new series are joined on common years so that the entire series employs a common unit base year. That is, if 1947 – 1966 are based on 1947=100, and 1967-1997 are based on 1965=100, the values from 1967 to 1997 are divided by the 1965 price to get all series in a common year. Of course, this is not the same thing as using a common base year for the weighting, and some of the changes in the time series may result from weighting changes. At least for the tramp shipping indices, the weighting scheme does not appear to matter overly much. Indices collected by the Norwegian Shipping News and the UK Chamber of Shipping tightly covary – the correlation coefficient between voyage rates collected by each is .87, and the correlation between voyage and time rates is .93 to .95.

Trade Data

The US trade data come from the US Census Bureau, “Imports of Merchandise” CD-ROMS, various editions. See Feenstra (1997) for details on a subset of these data.

The New Zealand data from 1964-1986 come from the serial “New Zealand Imports”. Statistics New Zealand provided data from 1988-1997 in electronic format. The break in the series provides two difficulties. First, the coding scheme changes from SITC Revision 1 to Revision 2 in 1979 and to Revision 3 in 1988, and this may produce some comparability problems in the series. However, higher revisions have been concorded backwards to Revision1, and goods are reported at the 2-digit level, so this is a fairly clean mapping. Second, the data source changes between periods, and the fob valuation of goods may not be the same in each case. Specifically, from 1964-1986 fob prices are based on goods valuation in the exporting country, and not directly from importer's declarations of the value of the goods as in 1988-1997. This results in certain goods having negative transport costs in some years. There are particular SITC codes for which this is a common problem. These are dropped from the calculations reported in the paper, though all the results are quite similar if these sectors remain in.

Appendix II: IMF CIF/FOB Ratios

In this section, I discuss the measurement of transportation costs using importer cif/fob ratios constructed from IMF sources, including the *Direction of Trade Statistics* (DOTS) and the *International Financial Statistics* (IFS). Both report trade flows using as a primary source the UN's *COMTRADE* database supplemented in some cases with national data sources. While the measurement of transportation costs are not the primary purpose of these publications, *DOTS* and *IFS* are sometimes used to this end.[50] In principle, exporting countries report trade flows exclusive of freight and insurance (fob), and importing countries report flows inclusive of freight and insurance (cif). Comparing the valuation of the same aggregate flow reported by both the importer and exporter yields a difference equal to transport costs. The advantage of using these data is breadth of coverage: they are available for many years (1948-1997) and for many countries (41 countries in every year, and over 100 countries are represented at some point in the data). The disadvantages of using these data are serious quality problems (discussed below) and depth of coverage (no data on commodity and country-pair cif/fob ratios).[51]

Figure A.1 reports a world-wide value for transportation costs as measured by the ratio of CIF to FOB valuation of trade. Two possible conclusions suggest themselves. One, transportation costs have declined precipitously – from 13 percent of trade to virtually zero from 1949 to 1995. Two, transportation costs were almost exactly constant at 3.5 percent of trade from 1953 to 1997. These data can also be used to examine trends in total transport costs in imports for each country. Out of 109 countries, 36 show a significant downward trend, 39 show a significant upward trend, and 34 exhibit no trend.

Unfortunately, the IMF data suffer from severe quality problems and broad inferences based on these numbers may be unwarranted. There are three serious problems. First, small discrepancies in the report of the importer or exporter yield large changes in cif/fob ratios. This

[50] Several recent papers, Baier and Bergstrand (1998), and Evenett, Djankov and Yeung (1998) use IMF data in studies of the role of transportation costs in world trade. Harrigan () employs similar data from the OECD in work examining measures of open-ness. Finally, the "Review of Maritime Transport" perhaps the most comprehensive source of data on international transport cites these data as a primary (and only systematic) source for ad-valorem shipping costs.

[51] Commodity and country-pair coverage could be extracted from the original data source, UN *COMTRADE* data. However, quality problems that are severe in aggregate data become truly execrable in country-pair and commodity data.

is easy to see by examining successive *DOTS* yearbooks. Each yearbook reports multiple overlapping years, with later years attempting to reconcile previous discrepancies. These changes are usually small relative to total trade, with variations no greater than one to two percent of trade annually. However, the changes can be large relative to cif/fob ratios.[52] As a consequence, the measured value of transport costs for a single year swings wildly about in different yearbooks. For example, the US cif/fob ratio for 1970 is reported variously as 1.13, 1.09, or 1.06, depending on which edition of the yearbook is consulted.

Second, exporter and importer reports of a trade flow may vary for reasons unrelated to shipping costs. It is well known that there are serious quality problems with export statistics as few countries make a concerted effort to measure outflows carefully. In a careful study of this problem, Yeats (1978) decomposes variation in the *COMTRADE* cif/fob factors into a transport cost component and other variation. The cif/fob ratio in the *COMTRADE* database is constructed using exporter (fob) reports, and US (cif) reports. US Census data also allows construction of cif/fob ratios, but these come directly from shipment documentation in which importers must report both the cif value and the explicit cost incurred in shipping. Assuming that the Census data is the true measure of shipping costs, Yeats matches the *COMTRADE* data to the US Census data for various goods and countries, and finds that much of the *COMTRADE* data variation is unrelated to true shipping costs. These ratios are especially noisy in developing country export data. However, Yeats also shows that these quality problems are less severe in more aggregated data. This leaves open the possibility that a time series on transportation costs drawn from aggregate data may contain useful information.

Third, and most troubling, for many pairings only one partner reports data and these constraints force the IMF to construct cif/fob ratios for most of the countries and years. This problem is severe in the UN *COMTRADE* data. Between 1962 and 1983, the data contain reports on aggregate trade flows from both partners for fewer than 40 percent of the bilateral pairings. Dropping those bilateral pairs with an implied negative transport cost (cif/fob ratios less than one), the data contain reports from both partners for fewer than 30 percent of pairings. Of course, the problem is much worse for trade reported at the commodity level, which raises the troubling question of the accuracy of the aggregate trade figures.

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[52] Starting with a cif/fob ratio of 1.06, increase the importer's cif value of trade by 1.5 percent and decrease the exporter's fob value by 1.5 percent. The cif/fob ratio becomes 1.09, a change of 50 percent.

In these cases, the IMF is forced to construct the cif/fob ratio using only one report. The somewhat sparse documentation in *DOTS* reports that a 10% increment over the fob value is used to construct the cif value or, alternatively, a 9% reduction from the cif value is used to construct the fob number.[53] This adjustment is applied to all country pairs and all time periods for which paired data are not available. (Though it appears that higher markups were used for some petroleum exporters in some years.)

This imputation pattern may explain two otherwise interesting facts in the IMF data. First, the mean and median importer cif/fob ratios are not declining over time because for the majority of countries, a constant cif/fob ratio is imputed. Second, imputation may pull cif/fob ratios down over time even if transportation costs are constant. Actual cif/fob ratios for developing country trade are much higher than the 10% imputation factor because much of this trade takes place in expensively shipped bulk commodities. Data quality on exports is worsening in developing countries. This forces an increased use of imputation that causes the cif/fob ratios to decline for importers of bulk commodities. Unfortunately, the documentation does not allow the user to carefully track where imputations have occurred, which countries they affect, or their time series properties. We know only that the data are pregnant with these corrections.

There are several ways one might check the reliability of the IMF data. The first is to examine the cif/fob ratio for each country over time to detect patterns in the imputation. Using the IMF *International Financial Statistics*, I plot the cif/fob ratio for each country for years 1948-1995. Examining the plots for several countries in Figure A.2, a clear pattern emerges -- the importer cif/fob ratio is very flat over long periods of time. The following table displays the number of times that the current year cif/fob ratio, f, exactly equals (to eight significant digits) its lagged values at lags of one to five years.

	Obs	N = 1	N = 2	N=3	N=4	N=5
$f_t = f_{t-n}$	4461	1475	1305	1256	1089	1026

[53] Some importers (including the US, Canada, New Zealand and Australia in some years), report imports on a fob basis. In this case, both exporter and importer flows are fob, and a similar 10% markup is used to generate the transport cost factor.

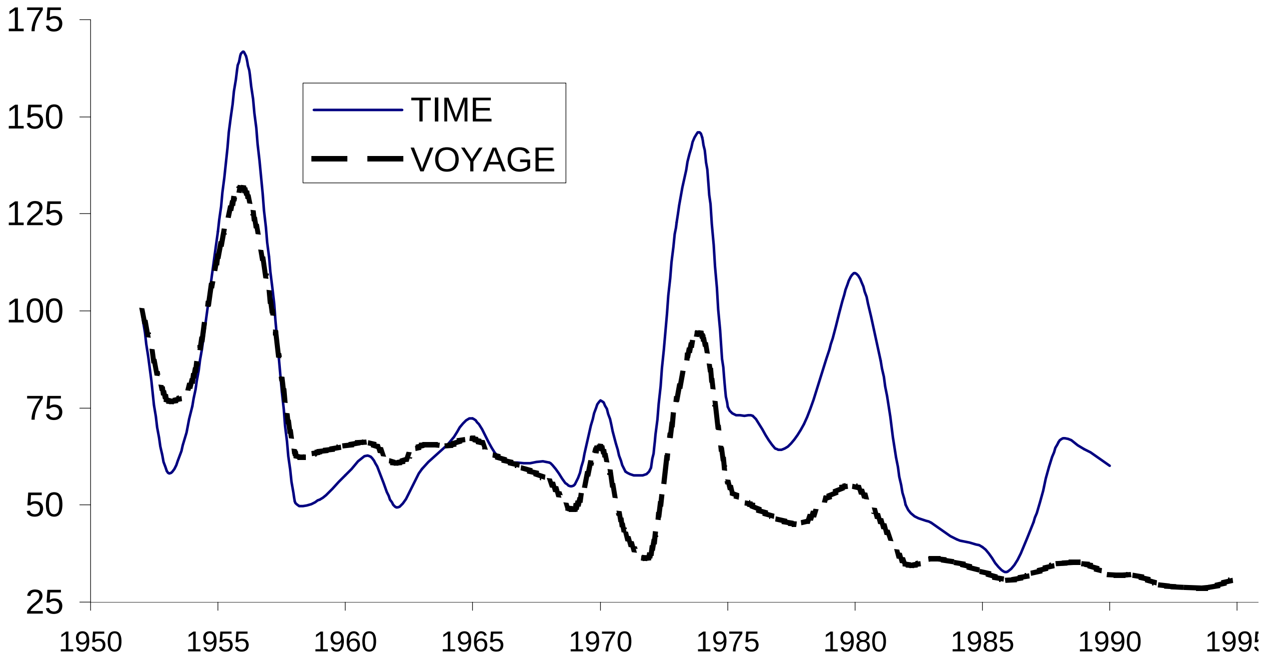
Nearly 25 percent of observations are identical to their five-year lags. This actually understates the constancy of these numbers since data for some countries alternates between fixed values, or returns to a constant value after a few years of variation (see Iceland and Ireland in Figure A2). To emphasize this, I calculate the modal value of the cif/fob ratio for each country and count the number of year observations equal to that modal value. Over the whole sample, approximately one-third of all observations for a country exactly equal that country's modal value, and around half of all observations equal the modal value rounded to four digits.

Recall, to construct the cif/fob ratios I collect two supposedly independent series, imports (cif) and imports (fob), from the *IFS*. Since very small discrepancies in either number will change the ratio substantially, it is clear that a large fraction of this data is imputed. That is, a fixed cif/fob ratio is combined with a known cif flow to generate an imputed fob flow (or vice versa).

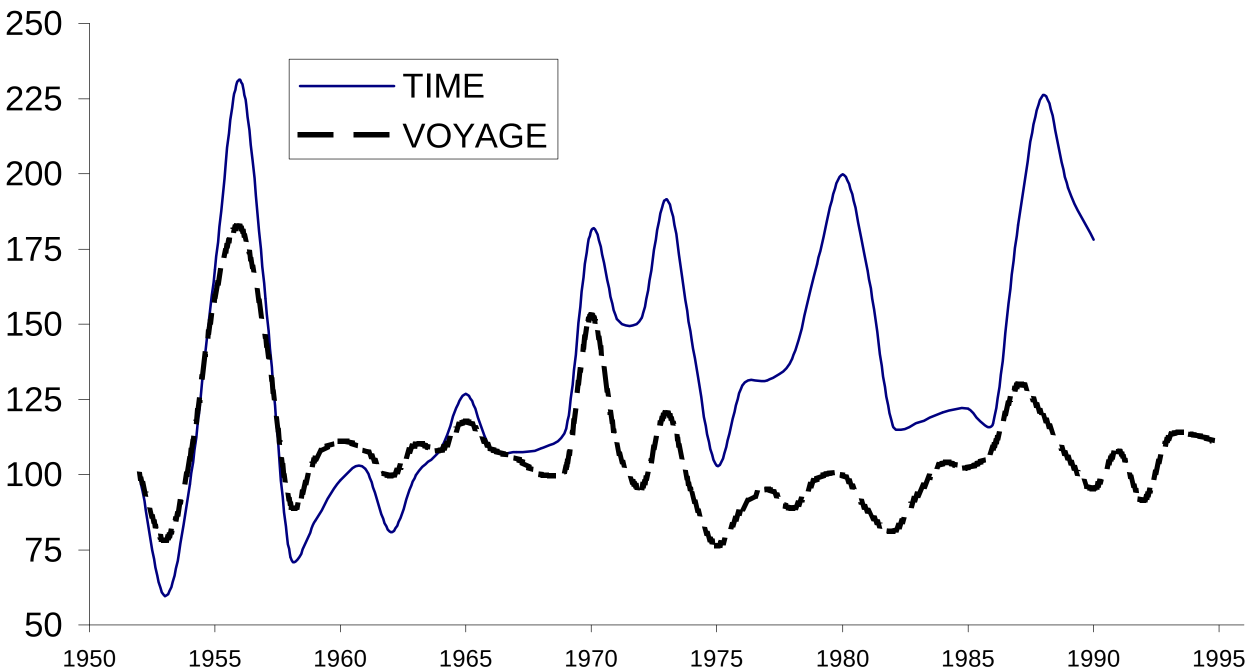
However, not all countries display such obvious signs of imputation. To check the reliability of the IMF's data for these countries, national data sources are useful. Both the United States and New Zealand require shippers to report measures of trade valued with and without freight and insurance costs on their import documentation. Taking the national data as the accurate source, the IMF *DOTS* yearbook data badly mismeasure both US and New Zealand transport costs, by a factor of two or more in some cases. However, the IMF data taken from *IFS* seems quite accurate for the US beginning in 1974 -- the year that US national sources began reporting both cif and fob values of the flow. A similar pattern holds in New Zealand's data. The IMF data taken from the *IFS* match New Zealand's national sources fairly well beginning in 1963 -- the year that national sources begin reporting both cif and fob values of the flow. In both cases, the IMF data displays a discrete jump from the previous trend in the year that national data become available.

Despite data quality problems, is there any information on the time series properties of transportation costs that can be extracted from the IMF data? This is a hard question to answer, as it is not clear for which countries the IMF has accurate data and for which they have relied on wholesale imputation. The world cif/fob ratio accords well with conventional wisdom regarding transportation costs. And, in those cases where it is possible to verify the IMF data against national sources, they appear accurate. (Although one suspects that the match between the *IFS* and national source data comes from using the relatively accurate US and New Zealand national data sources to correct poorly measured exporter (fob) reports. Essentially, the IMF data may be accurate because they discard their usual methodology in favor of using US data.) However, the sort of imputation displayed in Figure A.2 makes variation in IMF cif/fob ratios completely uninformative for most countries and suspect for the rest.

Figure 1 -- Tramp Shipping Rates



GDP deflator



Commodity price deflator

Figure 2 -- Liner Price Index Relative to Deflators

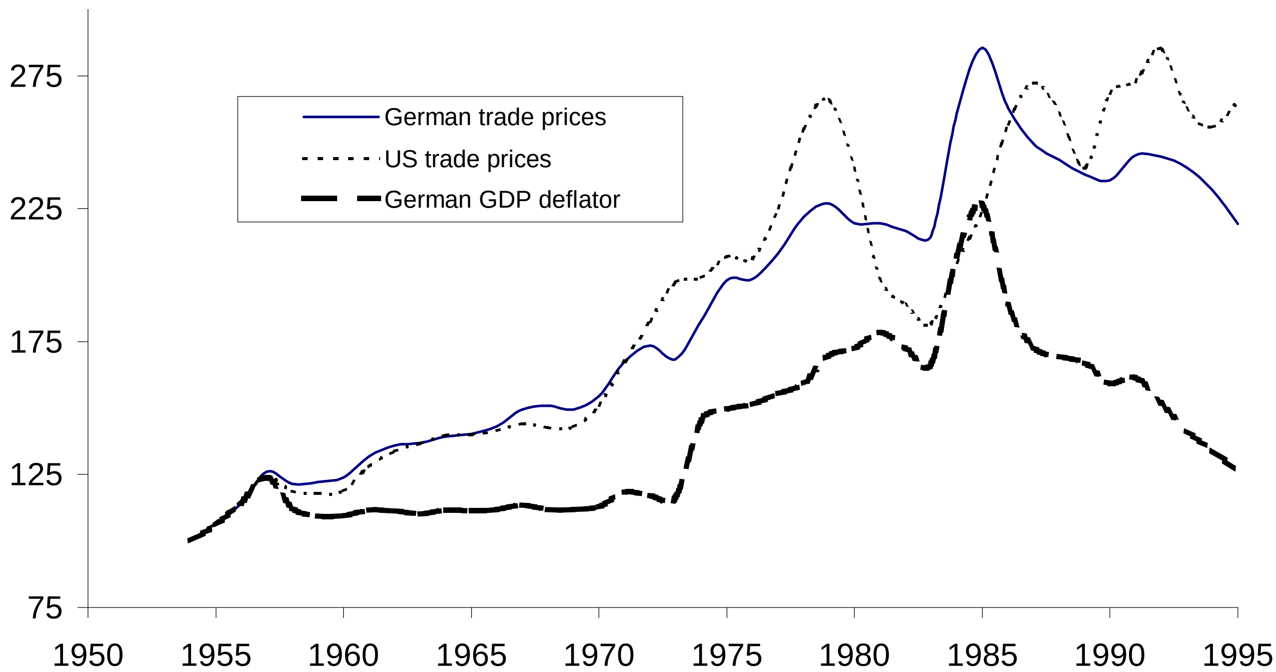
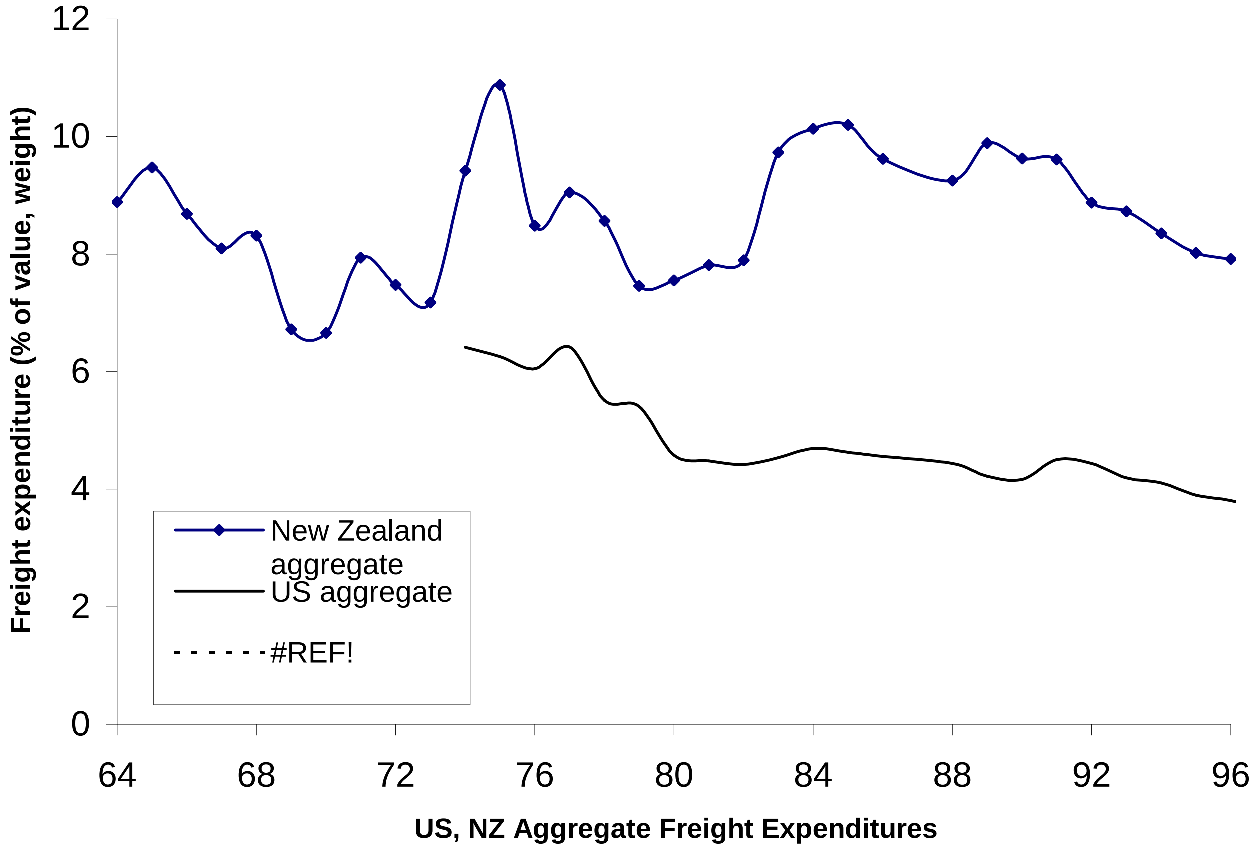


Figure 3 -- Aggregate Freight Expenditures



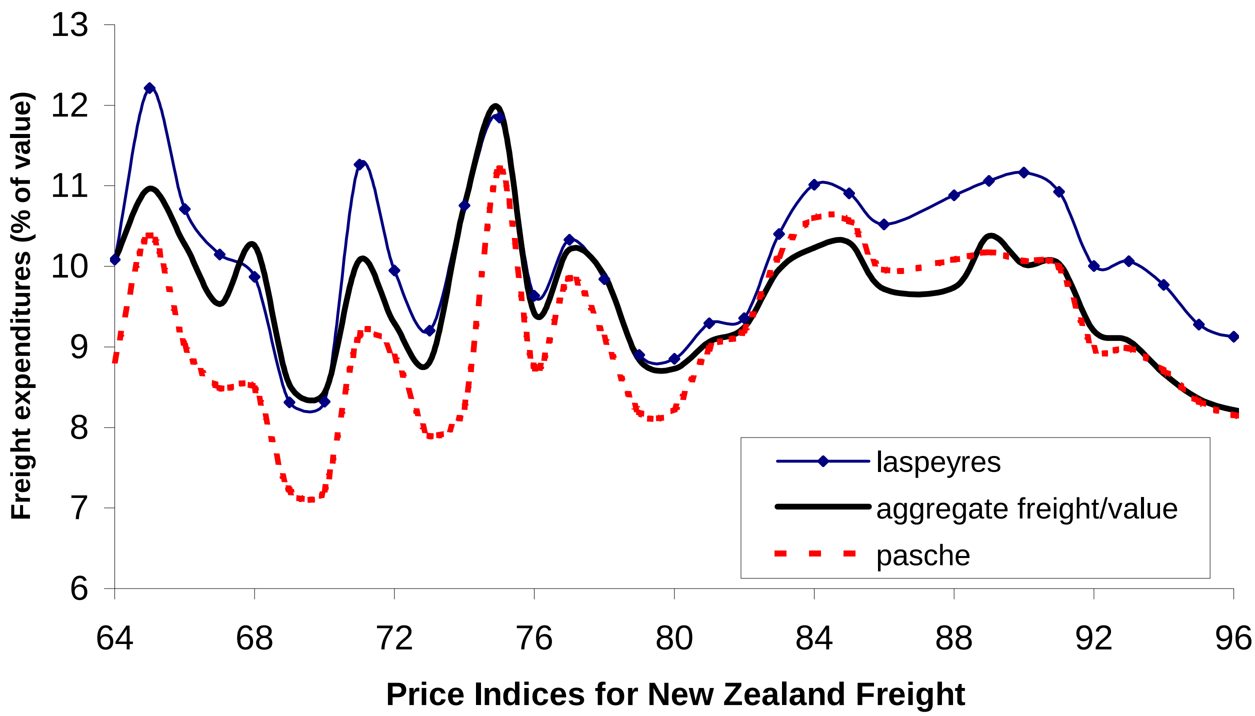


Figure 4

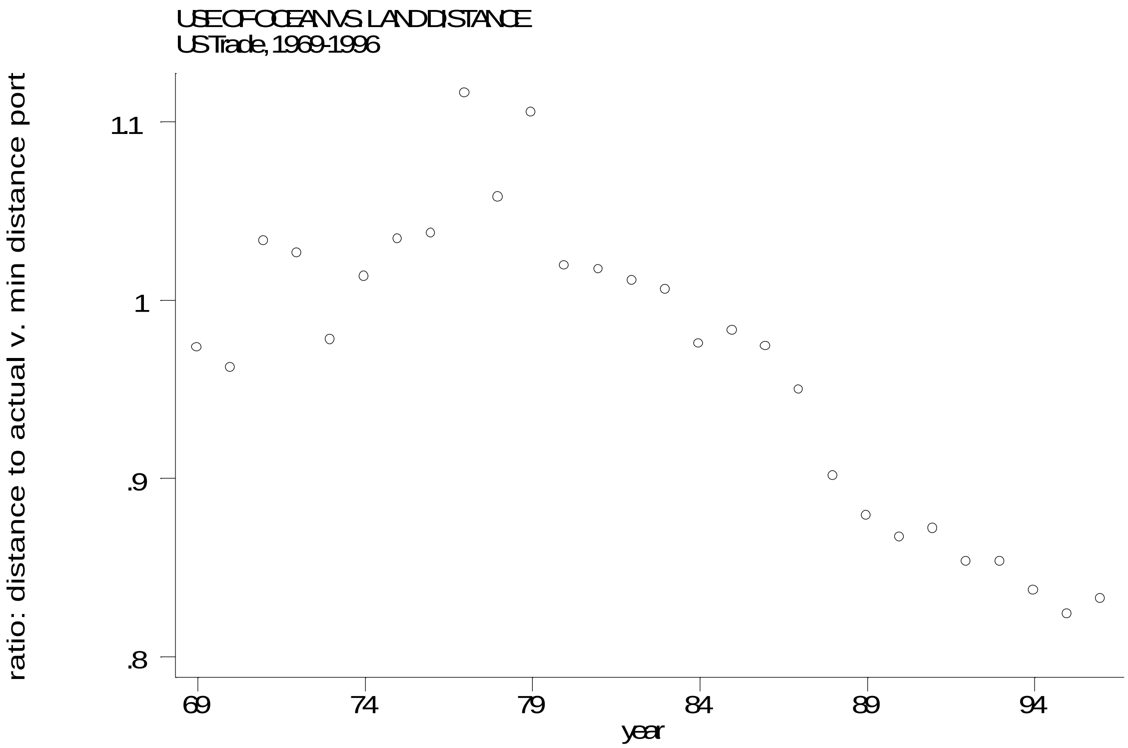

USE OF OCEAN VS LAND DISTANCE
US Trade, 1969-1996
ratio: distance to actual v. min distance port
1.1
1
.9
.8
69
74
79
84
89
94
year

Table 1 -- Liner Rates for Specific Commodities/Routes

Ad-Valorem Rates: Shipping Price Relative to Goods Prices

COMMODITY	ROUTE	1963	1965	1970	1975	1980	1985	1990	1996
Rubber	Malaysia-Europe	7.6	13.3	10.5	18.5	8.9	..	15.5	8.9
Jute	Pakistan-Europe	22.6	25.4	12.1	19.5	19.8	6.4	21.2	15.5
Cocoa Beans	Ghana-Europe	3.3	4.1	2.4	3.4	2.7	1.9	6.7	6.3
Coconut Oil	Sri-Lanka - Europe	11.2	7.2	8.9	9.1	12.6	12.6		6
Tea	Sri-Lanka - Europe	5.8	6.3	9.5	10.4	9.9	6.9	10	5.6
Cocoa Beans	Brazil-Europe	6.4	13.1	7.4	8.2	8.6	6.9	11	6.6
Coffee	Brazil-Europe	..	..	5.2	9.7	6	5	10	2.6
Coffee	Colombia - Europe	..	..	4.5	6.3	4.4	6.1	7.4	4.9

Quantity Rates: Shipping Price per ton (constant $)

COMMODITY	ROUTE	1963	1965	1970	1975	1980	1985	1990	1996
Rubber	Malaysia-Europe	130	206	111	194	155		106	99
Jute	Pakistan-Europe								
Cocoa Beans	Ghana-Europe	60	47	41	77	88	41	68	64
Coconut Oil	Sri-Lanka - Europe	88	65	64	62	97	64	0	25
Tea	Sri-Lanka - Europe	217	221	217	244	250	148	184	80
Cocoa Beans	Brazil-Europe	107	124	122	185	254	138	96	63
Coffee	Brazil-Europe			129	192	238	110	104	51
Coffee	Colombia - Europe			111	125	174	134	77	95

source: UNCTAD, Review of Maritime Transport, IMF International Financial Statistics

Table 3: Growth in International Air Transport

World-wide Growth in Air Cargo

Year	Ton-kms performed (mill) All flights	International	Int'l Cargo as a % of Total
1951	910	325	35.7
1955	1300	470	36.2
1960	2170	990	45.6
1965	4960	2590	52.2
1970	10460	6300	60.2
1975	17100	11300	66.1
1980	29130	20260	69.6
1985	39310	28920	73.6
1990	59163	46241	78.2
1994	76530	64090	83.7
Annualized Growth Rates			
1951-1994	10.6	12.8	

US Trade by Transport Mode (% of value)

year	Imports			Exports		
	Ocean	Air	Land	Ocean	Air	Land
1965	69.9	6.2	23.9	61.6	8.3	30.1
1970	62.0	8.6	29.4	57.0	13.8	29.2
1975	65.5	9.2	25.3	58.9	14.1	27.0
1980	68.6	11.6	19.8	54.8	20.9	24.3
1985	60.4	14.9	24.8	43.0	24.5	32.4
1990	57.2	18.4	24.4	38.4	28.1	33.5
1994	51.2	21.6	27.3	34.7	29.3	36.0

Sources: IATA, "World Air Transport Statistics", US Census, "US Imports", Statistical Abstract of the US

Table 4 -- World-Wide Air Freight Revenue
(Rates of Change by Decade)

	Revenues	Average Revenues per		Avg rev per ton-km controlling for distance elasticity	
		ton-km	ton	b=.81	b=.5
1955-1960	5.7	-9.0			
1960-1970	10.1	-8.5			
1970-1980	10.3	-1.8	1.2	-0.5	0.1
1980-1990	1.7	-6.3	-5.1	-6.1	-5.7
1990-1996	5.1	-3.0	-2.1	-2.8	-2.5

Source: IATA, World Air Transport Statistics

Note:
Final column assumes costs = a_t * ton * (km)^b
b=.81 estimate from ICAO Survey, all data worldwide, 1973
b = .5 estimate from US import data, air mode only, 1974

Table 5 -- Changing Air Fares by Region
(annualized growth rates)

years	Shipping price *per kg* *(1990$)* 1973-1993	Ad-valorem Air Freight Rate 1973-93	1973-80	1980-93	Distance Premium 1973-93
All Routes	-1.53	-3.48	-7.41	-1.30	-0.66
Developed Nation Routes					
North Atlantic	-2.22	-4.16	-7.39	-2.38	-1.37
Mid Atlantic	-1.26	-3.22	-5.17	-2.15	-1.72
S Atlantic	-1.13	-3.06	-4.28	-2.72	1.23
North and Mid Pacific	-2.39	-4.33	-11.48	-0.24	-0.42
South Pacific	-1.74	-3.69	-10.62	0.26	-0.41
Developing Nation Routes					
North to Central America	1.04	-0.97	-3.67	0.52	-0.57
North and Central America to South America	-0.14	-3.12	-6.19	-1.28	-1.98
Europe to Middle East	-0.58	-2.56	-3.93	-1.81	0.47
Europe and ME to Africa	-1.13	-3.09	-6.65	-1.11	-2.38
Europe/ME/Africa to Asia/Pacific	-0.92	-2.88	-5.29	-1.56	0.86
Local Routes					
Local Asia/Pacific	-0.95	-2.87	-8.68	-0.29	-1.84
Local North America	-0.80	-2.77	-6.84	-0.50	-1.09
Local Europe	-0.42	-2.39	-4.20	-1.41	-1.38
Local Central America	2.10	1.43		2.23	-1.11
Local South America	-0.83	-2.80	-6.01	-1.02	0.58
Local Middle East	-0.52	-2.50	-6.58	-0.23	-0.24
Local Africa	-0.14	-2.12	-3.80	-1.20	-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 6: Composition of Trade Growth

World Merchandise Exports Volume, 1950-1995
(Index numbers, 1990=100)

	Total	Agriculture	Mining	Manufactures
1950	9	26	18	5
1960	18	41	39	11
1970	41	61	77	29
1980	68	86	91	58
1990	100	100	100	100
1995	135	125	124	137

source: WTO

US Imports: Commodity Shares and Transportability

		Value Share in US Imports			Transportability (1995)	
SITC	Commodity	1969	1995	% Change 1969-95	(kg/$)	ad-valorem freight rate
0	Food & Live Animals	12.3	3.4	-72.3	0.96	7.64
1	Beverages & Tobacco	2.4	0.7	-69.0	0.67	7.05
2	Crude Materials	9.8	3.1	-67.9	6.90	7.63
3	Mineral Fuels	8.2	8.4	1.7	3.43	6.88
4	Animal & Vegetable Oils	0.4	0.2	-45.5	1.01	6.05
5	Chemicals	3.0	4.8	57.0	0.94	4.95
6	Manufactures (by material)	23.0	12.7	-45.0	0.89	4.85
7	Machinery & Transport Equip	26.8	46.2	72.2	0.06	2.25
8	Misc Manufactures	10.5	16.5	57.5	0.09	4.37

Table 7 --Freight Rates Over Time
(US Imports 1974-1996)

	OCEAN		AIR		BOTH	
	Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Weight/value	0.420	0.001	0.518	0.001	0.326	0.001
Distance	0.256	0.005	0.508	0.006	0.256	0.005
Distance * trend	-0.022	0.001	-0.017	0.001	-0.016	0.001
Distance * trend^2	0.001	0.000	0.000	0.000	0.000	0.000
Trend	0.179	0.009	0.128	0.011	0.127	0.008
Trend^2	-0.007	0.000	-0.004	0.000	-0.004	0.000
constant	-3.981	0.043	-4.827	0.055	-3.894	0.041

Dep var is ad-valorem freight rate from exporter j, port p, commodity k, time t.

Regressions include commodity fixed effects

Figure A1: World Transportation Costs as Measured by CIF/FOB Ratios
(IMF Direction of Trade Statistics)

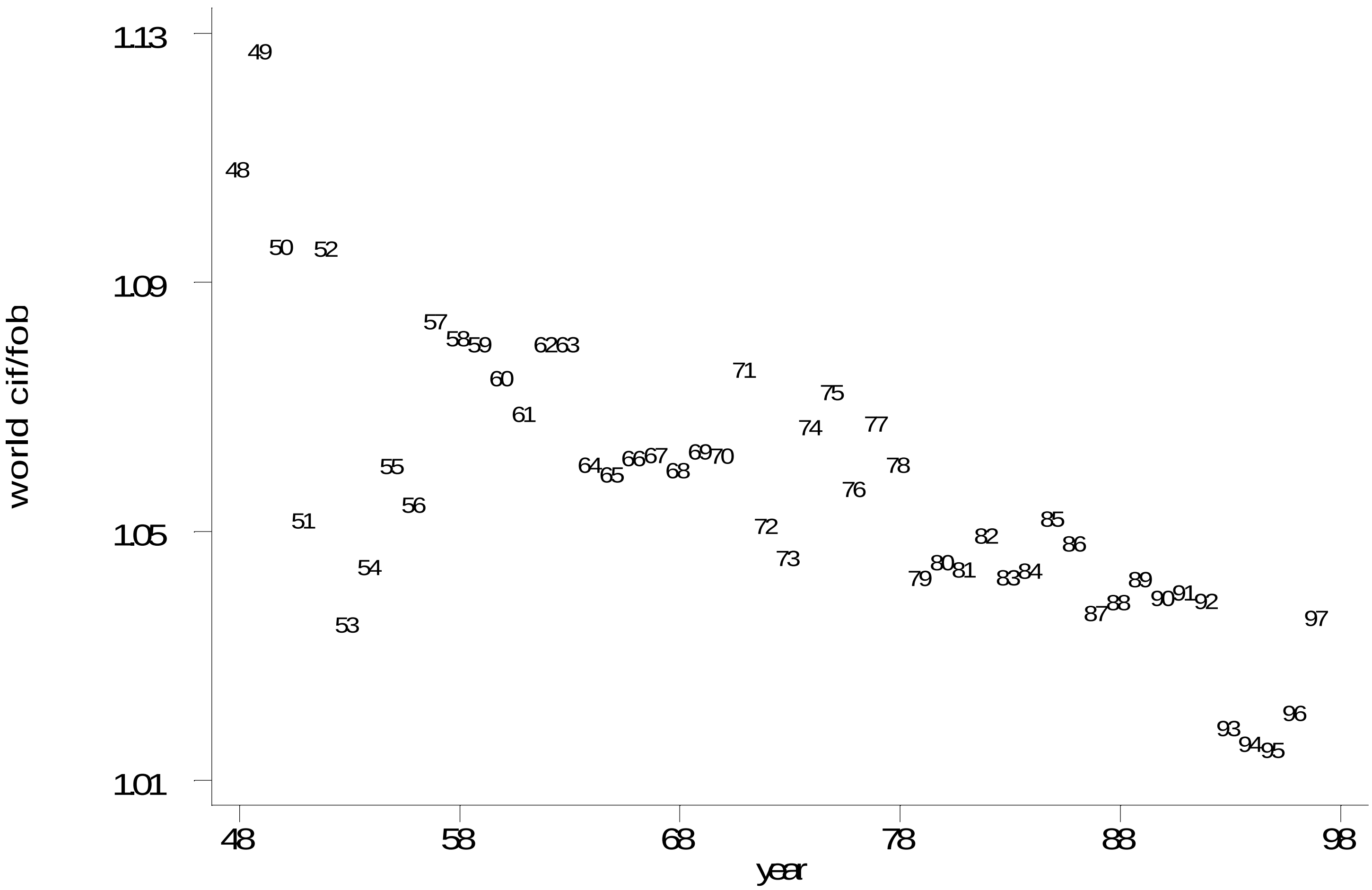


Table A1 -- Nominal Values of Shipping Price Indices

	Tramp Charters Shipping Indices					Liner index
	Voyage	Time			Composite	
	NSN	UKCS	NSN	GMT	BFI	GMT
1952	113	100	115			
1953	88	61	68			
1954	94	72	88			100
1955	130	130	140			108
1956	152	173	197			119
1957	125	120	139			132
1958	78	56	64			122
1959	79	56	65			120
1960	82	65	74			122
1961	84	73	81			127
1962	78	58	65			131
1963	85	69	79			133
1964	86	78	88			138
1965	90	88	99			142
1966	86	87	88			148
1967	85	85	88			152
1968	83	91	92			153
1969	77	92	88			155
1970	107	165	130			162
1971	73	85	103			179
1972	67	89	108			187
1973	146	230	237			199
1974	196	258	310			266
1975	128	114	176			290
1976	121	117	180			305
1977	120	95	169			325
1978	126	134	201			342
1979	161	228	284			379
1980	192	312	392			406
1981	176	235	344			448
1982	143	121	210			456
1983	153	118	197			454
1984	156	144	185			579
1985	150	124	183	100	100	646
1986	142	106	156		79	538
1987	157	163	225		112	494
1988	176	263	340	118	152	490
1989	184	297	347	139	170	497
1990	178		341	106	149	486
1991	185			121	175	510
1992	176			96	132	504
1993	176			125	154	491
1994	181			114	163	478
1995	203			124	218	458
1996	174			88	145	474
1997	176				160	495

NSN - Norwegian Shipping News; UKCS - UK Chamber of Shipping
GMT- German Ministry of Transport; BFI - Baltic Freight Index (Baltic Freight Exchange)