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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 brings to bear an eclectic mix of data in order to provide a detailed accounting of the time-series pattern of shipping costs. Direct evidence on prices and indirect evidence on quantities show that ocean freight rates have increased while air freight rates have declined rapidly. These changes are linked to technological and institutional factors. In particular, containerization in ocean transport is shown to have changed the composition of freight rates (lowering the cost of distant relative to proximate travel), but not reduced the level of rates until only recently. Finally, the paper offers insights into how changes in the nature of transportation may affect the composition of trade and integration.

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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 offers two contributions. First, it provides a detailed accounting of the time-series pattern of shipping costs for both air and ocean transport. Second, it relates changes in transportation technology and institutions to changes in the level and structure of freight rates.

A better understanding of international integration, its causes and consequences, requires the careful measurement of barriers to that integration. The level of trade barriers matters 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

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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 3, 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.

in shipping costs can be directly interpreted in terms of their effect on trade -- all trade 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, as detailed in the next section, direct investigations of the relative importance of shipping versus tariff barriers in the cross-section consistently identify shipping costs as the more important barrier. This 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, no single source of data provides a definitive picture of the costs of transport. Matched partner trade data from the IMF promise great breadth of coverage and have been used by a number of authors to assess transportation costs across countries and over time.[4] The time series derived from IMF sources accords well with conventional wisdom -- transportation costs have declined steadily while trade has grown (see appendix Figure A1). However these data are subject to two serious problems. First, as Appendix II 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 set of partners with whom a country trades, will affect measured costs even if the unit cost of shipping remains unchanged.

Lacking a single, comprehensive data set, this paper gathers together an eclectic mix of data on prices and quantities for international ocean and air transportation. Primary 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 collected by customs agencies in the United States and New Zealand. Information on overland transport is not provided as data are much harder to obtain, and in any case, regulation of and infrastructure for overland transport are sufficiently different across countries that information gleaned from one source would have little relevance to other markets. Similarly, a direct evaluation of quality change in transportation services is beyond the scope of this paper as is the

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[4] 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. See footnote 1, and Harrigan (1993) for studies employing matched trade flow data to generate transport costs.

provision of quality-adjusted price indices. Given that we know very little about transportation costs over time, whether quality adjusted or not, the present approach seems a reasonable first step. However, the paper does point to potential sources of quality change so that they may be pursued in future work.

Section 2 offers a brief overview of international transportation. Section 3 provides data on the price of ocean transport. Index numbers indicate substantial increases in the price of liner shipping, which comprises the majority of world trade. Extremely detailed United States customs data are employed to identify the role of technological and institutional change in shaping the time series in freight rates. The data show that containerization changes the composition of freight rates but does not reduce the overall level of freight rates until the late 1980s. Route density also plays an important role; freight rates drop most on routes where trade has increased most. This may reflect either a competitive intensity effect, or the importance of scale economies in route size. Finally, cargo reservation policies, in which developing countries reserve a substantial share of shipping for national-flag fleets, helps explain differences in rates across countries as well as rising rates through the late 1970s and early 1980s.

Section 4 provides data showing steady and sizeable declines in the cost of air transport. Comparative data indicate that the largest price declines have occurred on longer routes and routes involving the US. Finally, as a check on the price trends revealed in the data, Section 5 demonstrates that modal use varies in a manner consistent with relative price movements. Section 6 concludes with a set of important research questions posed by these surprising results.

II. International Transport: An Overview

This section provides an assessment of the importance of transportation costs in trade and overviews relevant technological and institutional details. How important are international transportation costs? Several authors have researched this question in the cross-section, employing data from a variety of countries over a thirty-year period.[5] The consistent finding is that transport costs pose a barrier at least as large, and frequently larger than tariffs. Moreover, unlike tariff rates, freight charges vary considerably over partners, implying an especially large

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[5] 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. Hummels (1999) reports data from seven countries in 1994.

role for transport costs in determining bilateral variation in trade. The most recent study, Hummels (1999), employs customs data from the US, New Zealand, and five Latin American nations in 1994 and finds aggregate expenditures on freight ranging from 4 to 13.3 percent of total import volume.

These data actually understate the level of total transport charges to a considerable degree. First, customs data typically cover only the international leg of transport, omitting port and inland charges. Case study evidence shows that international ocean freight comprises only a third of total door-to-door shipping charges, and this fraction has changed little over time.[6] Second, aggregate ad-valorem freight rates are simply a trade-weighted average of freight rates for individual (exporter x commodity) observations. If import choices are made so as to minimize freight costs, aggregate rates will understate true rates. Unweighted mean freight rates for the US range between 12 and 15 percent ad-valorem, or roughly two to three times the trade-weighted rates.

Customs reports can be used to provide a simple characterization of (purely international) transportation costs over time. Figure 1 reports time series variation in aggregate ad-valorem freight rates for the US and New Zealand. (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 longer New Zealand series show rates fluctuating between 7 and 11 percent of import value but not declining over time. Data on freight charges in US trade begin in 1974, an especially unfortunate year for current purposes. The New Zealand data, and all the series explored in the next section, show freight cost increases of at least 30 percent between 1973 and 1974 due to the oil shock, and larger increases going back to 1970. While US data exhibit declining rates from 1974-1998, imputing 1973 values from other sources (that is, reducing 1974 values by 30 percent) eliminates nearly all of this decline.

Of course, these aggregate data are subject to important compositional effects. If trade growth occurs primarily in cheaply-shipped commodity groups, this will cause a decline in the aggregate ad-valorem rate. Table 1 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

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[6] A 1967 OECD study of shipments between OECD trading partners showed that international ocean freight comprised only 38-64 percent of total door-to-door shipping charges. Livingston (1986) found that the ocean leg typically comprised one-third or less of total shipping costs from European to African partners. The author has

transportability – the weight-to-value ratio and expenditures on freight relative to value in each category. Trade in easily transported manufactures (SITC 5-9) grows while trade in expensively shipped commodities (SITC 0-4) shrinks. The same pattern occurs worldwide. Index numbers constructed by the WTO show that from 1950-1995, trade in manufactured goods grew much more rapidly (27-fold) than either agriculture (5-fold) or mining (7-fold) products.[7] These changes make it difficult to clearly discern the time series pattern in shipping costs from aggregate data, and suggest the need for more careful decompositions.

In addition to addressing the composition of *what* is traded, a rich story of international transport in the post-war era should also consider *how* goods are transported. Transport of dry (non-oil) cargo can be divided into three categories: tramp ocean shipping, liner ocean shipping, and air shipping.[8] Tramps are used for shipping large quantities of bulk commodities on a charter basis, with prices set in spot markets.[9] Liners are used for general (that is, all but large quantity bulk) cargoes and ply fixed trade routes in accordance with a predetermined time-table. Traditionally, the liner trade has been organized into cartels, or conferences, which fix shipping prices for a year or more at a time. (The extent to which these cartels are able to successfully price discriminate and charge monopoly markups is an open question in the literature.) Finally, air transport is used primarily for time sensitive goods as well as those with low weight-value ratios. To give an idea of the relative importance of each, Table 2 shows the evolution of transport modes for US trade. The value of air shipped trade has grown from negligible amounts in 1950, to 7 percent of trade in 1965, to nearly 30 percent in 1998. Roughly two-thirds to three-quarters of world ocean trade by value is moved via liners.[10]

There is no reason to think that ocean and air transport have undergone similar technological and institutional change, and so their price series need not be similar. Indeed, the

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surveyed door-to-door costs in 1999 using online tariff quotation systems from large shippers such as Evergreen, and consistently found ocean costs equal to one-third of total costs.

[7] These rates refer to growth in the quantity of trade in each category. Measuring growth in the value of trade, manufacturing trade grew 100-fold while agriculture and mining trade grew 15 and 50-fold, respectively.

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

[9] In recent years, a small fraction of containerized tramps have been employed to lift general cargoes. Tramp shipping is organized through information clearing houses such as the Baltic Freight Exchange that match demanders and suppliers of bulk shipping services. The exchange also offers thinly traded futures contracts on shipping services.

[10] Careful calculations reported in *MARAD*, various years, reveal that the liner share of US non-tanker trade by value in 1956, 1976, and 1996 was 83, 66, and 78 percent respectively. Noisier estimates for 1970 put world-wide liner

dramatic changes in modal shares suggest important relative price movements. Moreover, to the extent that these modes are employed for different goods and for different purposes, understanding relative movements in modal prices may provide useful insights into changes in the nature, as well as the extent, of international integration.

III. Ocean Transport

Ocean shipping has undergone several important technological and institutional changes in the post-war era, including the growth of open registry shipping, the introduction of containerization, and the institution of cargo reservation policies in developing country trade. Open registry shipping is the practice of registering ships under flags of convenience (e.g. Liberia, Panama) in order to circumvent higher regulatory and manning costs imposed by wealthier nations. Open registry fleets comprised 5 percent of world shipping tonnage in 1950, 25 percent in 1980, and 45 percent in 1995.[11] 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.[12]

In 1966, the first container ships with international service appeared on North America - Europe routes, with North America-Far East and Europe-Far East routes appearing 2 and 3 years later. After introduction, containerization grew rapidly, but primarily, on these three routes. By 1980, 73 percent of US liner tonnage to continental Europe and 81 percent of US liner tonnage to the Far East moved via container.[13] Growth on other routes occurred much later. Between 1982 and 1995, container use in developing country ports grew 15.5 percent per annum, increasing from 24 to 50 percent of worldwide container traffic.[14]

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trade at 60 percent (Lawrence, International Sea Transport) to 66 percent (OECD, *Maritime Transport*). Liner shipping is responsible for perhaps 15-25 percent of trade by weight.

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

[12] Savings vary inversely with ship size as manning expenses represent a smaller portion of total costs for large ships.

[13] MARAD, and Containerized Cargo Statistics. The percentage figures refer to container tons relative to liner tons on these routes. Containers are moved primarily, though not exclusively, via liner, so the ratio may exceed one.

[14] Calculations from data on number of containers lifted by port, reported in UNCTAD, RMT. These figures include traditional entrepots Hong Kong and Singapore. Excluding them reduces the developing country share of container traffic to 16 and 35 percent of world traffic in 1982 and 1995 respectively.

Containerization is thought to be an important source of improved shipping efficiency, both in and out of port.[15] Port usage imposes direct 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: various estimates place conventional (non-container) ships' time in port at one-half to two-thirds of the ship's life. Containerized cargoes are packed once at the factory door rather than at every change in transport mode, thereby reducing direct costs as well as the ship's time in port.[16]

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.[17] Because containerships spend more time steaming, investments in larger, faster ships become feasible. In 1970, the average containership was 36 percent faster, and X percent larger than the average non-container general cargo freighter.[18]

This logic implies two additional effects. The first is "distance-biased technological change". Large and expensive containerships are used primarily on long routes in order to minimize the percentage of a ship's time spent idle in port. Thus, the introduction of containerization should reduce the ocean leg cost of long routes relative to short routes.[19] Second, because containerships are larger, faster, and spend less time in port it takes fewer ships to service a particular trade route.[20] Gilman (1983) hypothesizes that this may result in increased market concentration for liner conferences and greater monopoly power in setting prices.

Finally, in the late 1970s many developing countries adopted cargo reservation policies designed to ensure that national-flag fleets were granted a substantial portion (usually 40 percent) of liner traffic in that country's trade. The thinking, enshrined in UNCTAD's Liner Code of Conduct, was that developed country liner fleets were already extracting significant

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[15] UNCTAD, Unitization of Cargo, used a simple model to calculate savings estimates as high as 60 percent, with estimates depending critically on capacity utilization, and reduced stevedoring costs. A similar 1967 McKinsey study predicting savings of 50 percent.

[16] UNCTAD, Unitization of Cargo estimates port time savings of up to 60 percent for containerships.

[17] See Gilman (1983) for estimates of scale economies in ship size, and McKinsey (1967) for an analysis of the port time / ship size trade-off. Larger ships also pay higher berthing fees.

[18] US Maritime Administration, "A Statistical Analysis of the World Merchant Fleet". Average speeds are 19 knots for the container fleet, 14 knots for conventional freighters.

[19] Since port costs represent a larger overall fraction of costs on short routes, the effect of containerization on the relative door-to-door costs of long and short routes is unclear.

[20] McKinsey (1967) estimates 70 percent fewer containerships would be required to service the Atlantic fleet.

rents from shipping; it therefore seemed only “fair” that the shipowners in the developing world should share those rents. It has subsequently been suggested that these policies simply isolated domestic shipowners from competition, leading to higher rates.[21]

Price Indices

Have technological and institutional changes resulted in lower ocean shipping prices? To answer this while also addressing compositional concerns, I provide index numbers for unit prices ($/quantity) of ocean-borne shipping. Price 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, constructed by the *Norwegian Shipping News (NSN)*, cover voyage charter and time charter tramp shipping. A voyage charter is a contract to ship a large quantity of a dry bulk commodity between specific ports. Rates are generally quoted as US$ per ton and may include some minimal loading and/or unloading expenses.[22] The *NSN* voyage charter price index represents a weighted bundle of spot market prices ($/ton) for shipping major bulk commodities on several important routes world-wide. A time charter is a contract to employ the services of an entire ship for a set period of time (usually up to a year). Weekly rates are quoted in terms of US$ per dead-weight tonnage of the ship, and generally include only minimal port services. The *NSN* 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 differs from the other series in a few important respects.[23] 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 commodity composition of the majority of world trade. However, the index includes only those liners loading and unloading in Germany and Netherlands, rather than offering comprehensive geographic coverage. Finally, unlike tramp shipping, liner prices include port costs and charges.

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[21] See Bennathan (1989) for a detailed analysis of the effects of cargo reservation on Chile’s shipping industry.

[22] 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.

[23] Pricing formulas for liner shipping differ across goods, with prices fixed variously in weight, bulk, and/or value terms.

The nominal values for the price indices are reported in Table A1 of the appendix. To evaluate the real costs of shipping over time, an appropriate deflator must be chosen. Tramp prices are set in intensely competitive markets and quoted in US$; accordingly I deflate these indices using both the US GDP deflator and a price index for bulk commodities typically shipped via tramps.[24] Using the US GDP deflator provides a constant dollar value for the unit price of tramp shipping a given quantity of merchandise. Of course, countries experiencing a real appreciation (depreciation) relative to the dollar will enjoy lower (higher) shipping prices. Using the bulk commodity price index yields the price of shipping a bundle of goods relative to the price of that bundle, essentially the ad-valorem barrier posed by shipping.[25] For many purposes such as measuring the limiting effect of shipping on trade, the ad-valorem equivalent of the barrier is the relevant measure.

Choosing an appropriate deflator for the liner index is more difficult. While rates are quoted in dollars, liner conferences frequently apply currency adjustment factors to compensate for fluctuating exchange rates. That is, when facing a dollar depreciation, conferences may levy a surcharge to keep the foreign currency price of shipping services constant. The extent of the adjustment, or exchange rate pass through, is unclear. Accordingly, I employ both a German and a US GDP deflator as bounds. The German GDP deflator is appropriate in the case of complete passthrough, when prices are adjusted to hold DM prices constant. The US GDP deflator is appropriate in the complete absence of passthrough, when dollar prices are held constant.

Figure 2 reports movement in the liner shipping price index relative to the German and US GDP deflator. Relative to the baseline year (1954=100), prices rise steadily through 1970. Prices rise sharply through the 1970s, peaking in 1985, then declining rapidly thereafter.[26] The largest single rise occurs between 1973 and 1974. Note that rates rising through 1985 and declining thereafter closely matches the aggregate New Zealand freight expenditure data from Figure 1.

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[24] The index is constructed using the same goods and weights as used in the NSN voyage charter index. The time charter index is based a bundle of ship sizes, and not on cargo type. 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. All commodity price series are taken from IMF, *International Financial Statistics*.

[25] 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.

[26] The difference between the two deflators from 1975-1983 is notable, as prices relative to the dollar deflator decline by 0.6% per year, while prices relative to the DM rise by 2.2 percent per year. The difference reflects higher dollar inflation rates in this period.

The especially rapid liner price increases that occur in the 1970s for German trade appear to have occurred more broadly. Indeed, the "problem" of liner rates was sufficiently severe and widespread that several national agencies and the UN commissioned studies to determine the source of the rate increases. Throughout the 1970s, UNCTAD's annual *Review of Maritime Transport* reported in some detail the tariff increases (and surcharges of various kinds) levied by shipping conferences. Annual nominal increases of 10-15 percent were common across nearly all routes.[27] Studies of rates on US North Atlantic liner routes found real increases (relative to the dollar deflator) ranging from 21 to 26 percent between 1971 and 1975, comparable to those found in German trade.[28] Finally, 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. Appendix Table A2 shows that ad-valorem rates have fluctuated considerably, but not declined between 1961 and 1996. Measured in price per ton equivalents, these rates show dramatic real increases – 67 percent on average -- between 1970 and 1980.[29]

Figure 3 displays 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,[30] 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.[31] 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.[32] This indicates forty years of fluctuating, but not declining, real prices. The second panel of Figure 2 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

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[27] Ideally, one would employ these data to construct a liner price index number with more general coverage. Unfortunately, the survey lacks data necessary to construct weights and covers too few years to be of much use in this regard.

[28] Sletmo and Williams (1981) report nominal rate increases of 61 to 103.5 percent.

[29] The data are converted to price per ton using series on commodity prices from the IMF.

[30] 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.

[31] 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.

[32] 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.

shipping, yielding no change or even increases in the ad-valorem barrier to trade posed by international transport.[33]

Recall, containers were introduced to European liner trades with North America and the Far East in the late 1960s, with penetration into developing country liner routes occurring primarily after 1980. 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 in absolute terms and relative to tramp prices after containers are introduced. This is very surprising and raises two important questions. Why are liner rates rising through the 1970s and early 1980s, and what explains the relative movements in the tramp and liner series?

To answer these questions, I first provide some specific though limited data on vessel operations and port costs. These data come from case study and engineering evidence and primarily cover the period in the 1970s when German liner rates rise very rapidly. They are insufficiently detailed to "explain" the 45-year time series in liner prices, or to estimate cost functions for shipping. However, they are useful for demonstrating that the German liner price increases appear general and linked to operating cost increases. In addition, the data provide some explanation for the diverging liner and tramp series.

Sletmo and Williams (1981) report the following annual rates of increase in operating costs facing liner shipping in the 1970s.

Cost Category	Annual % increase	Cost Category	Annual % increase
Total Operating Costs	14-18	Fuel	30-60
Vessel Operating Costs	12-14	Containership price	30-38
Seamen's Wages	10-22	Container price	16-19
Cargo Handling	11-16	Overall $ GDP deflator	7.5

When oil prices more than quadrupled in 1974, vessel operating costs for both tramps and liners rose dramatically. This can be clearly seen in Figures 2 and 3. The effect was especially pronounced for containerships, whose higher speeds require greater rates of fuel consumption.

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[33] 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.

One study estimated an 86 increase in containership vessel operating costs from the 1974 oil shock alone.[34] Similarly, shipbuilding prices increased fleet-wide, but rose twice as fast for containerships as for conventional freighters.[35]

Finally, liner prices cover both vessel operating costs and port costs while tramp prices include only vessel operating costs. (Port costs for tramps are generally borne by the persons shipping goods, not the shipowners, and so are not included in published prices.) An UNCTAD 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.[36] This suggests that the price of tramp shipping inclusive of these charges may have increased substantially throughout the 1970s. The port cost data also provide a critical point regarding containerization. One of the main expected effects of containerization was a reduction in port costs. Liner data that include these costs, and direct evidence on port costs in the ten years after their introduction, show no resulting declines.[37]

The role of technology and institutions: evidence from US customs data

These cost data go some distance toward explaining the rising liner rates of the 1970s and 1980s. Customs data from the US provide an opportunity to more fully investigate the pattern of freight rates over time, and to explore the causes of freight rate movements. The simplest exercise employs detailed information on shipment characteristics in order to extract a time series on shipping costs controlling for compositional effects. Customs data are also combined with evidence on differential rates of technological adoption (containerization), industrial policy (cargo reservation) and market structure (route density) to identify the role of technology and institutions in determining the level and structure of freight rates.

"US Imports of Merchandise" available from the US Census Bureau provides shipment characteristics including transport mode (air, ocean, land), weight, value, freight and insurance

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[34] 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.

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

[36] UNCTAD, 1977, "Port Problems: causes of increases in port costs and their impact". The study cited rapidly rising labor costs, and overinvestment by port authorities combined with average cost pricing in the absence of competition.

[37] Of course, port cost increases may have been even higher in the absence of containerization.

charges, and duties, with exporter (all countries) x commodity (5 digit SITC, or roughly 3000 goods) x port of entry detail. Freight charges for ocean shipping are calculated on a port to port basis and do not include inland costs.

In the initial exercise I use detailed information on shipment characteristics in order to extract a time series on shipping costs controlling for compositional effects. A simple 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

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

The regression controls for distance shipped and shipment weight-value, while commodity fixed effects soak up 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 similar when using higher order polynomials or when year and year*distance interactions are employed.) Good k refers to a 5-digit SITC commodity, and the time period spans 1974-1998.

Table 3 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 ocean shipping this precisely captures the predicted effect of growing containerization on the structure of freight rates. To test this effect, I restrict the sample to include only those trade routes where containers were introduced extensively after 1980. In this sample, the distance coefficient is constant from 1974-1980, then falls only after containers are introduced.

To evaluate the year to year trend in freight rates, I estimate a more general specification with year and year x distance interactions. I evaluate the regression at the variable means for routes of 1-,5-, and 9000 kilometers, and plot predicted values in Figure 4. Values prior to 1974 are imputed from the longer series provided in this section.[38] The picture now closely resembles the liner series described earlier – rising rates through the 1970s, peaking in 1985, with declines thereafter. Also, the relative change in prices for short and long routes can be clearly seen.

As a final exercise, US customs data allow a fuller explanation of the evolution of freight rates. I explore the role of four technological or institutional shocks: oil prices, containerization, route density, and cargo reservation policies pursued by developing countries. Oil prices are the single largest component of vessel operating costs, and casual empiricism suggests a nice match between their movement and overall freight rate movements (both the 1974 shock and the declines after 1985).

Does containerization lower shipping rates? The rapid adoption of this technology makes a strong case for efficiency gains, but these may be confounded by the cost shocks outlined above. This suggests that shipping rates have increased *despite* containerization. It may also be that shipping rates have increased *because of* containerization, to the extent that it results in greater market concentration and monopoly power for shipping cartels.

To test these effects, I exploit two sources of variation to examine whether the use of containerization is related to shipping rates. The first estimates the relationship at a point in time, so that cost shocks are held constant and uses data on the intensity of containerization across routes. Sources from the US Maritime Administration yield the percentage of liner tonnage that is containerized by trade route from 1971-1983, with extremely detailed commodity x country coverage from 1990-1998.[39] For the intervening years, a somewhat cruder proxy is employed. UNCTAD, *Review of Maritime Transport*, various years, reports the number of containers lifted by developing country port from 1978-1998. The same data are also used to exploit within variation to see if the first time introduction of containers, or increases in the extent of containerization along a particular route lead to lowered freight rates.

A second institutional shock is the steady growth in trade volumes, which might operate through two separate channels. First, suppose that bigger containerships raise the fixed costs of serving a shipping route, foreclosing entry. Presumably then, routes with greater volume can sustain more entrants, intensifying competition and lowering prices. Second, even if shipping is

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[38] The New Zealand data, the liner and both tramp indices all show freight rate increases of around 30 percent from 1973-1974 so 1974 levels are decreased by 30 percent for 1973

[39] Data from 1971-1983 are reported in “Containerized Cargo Statistics” and “MARAD Annual Report”, various years.

highly competitive, increased volumes may lower costs due to the realization of scale economies in route size. This is essentially an argument that integer constraints are important – more heavily traded routes allow the introduction of cargo-specific specialized ships, more direct routing (as fewer ports are required to fill the ship), and more frequent sailings. I examine whether shipping rates vary with route density, the total weight or value shipped on that route. As this is clearly endogenous to the freight rate, I instrument route density using tariff rates, and GDP of countries on the route.

Finally, many developing countries reserve substantial portions of trade for national-flag fleets, potentially forestalling entry by foreign competitors. The particulars of cargo reservation policies in developing countries are difficult to ascertain without exhaustive country by country case study. A useful proxy is the size of the merchant fleet in each country. Bennathan (1989) demonstrates that the size (total tonnage) of the Chilean flag fleet rose dramatically after reservation policies were enacted, and fell when they were removed. Data from the *RMT* on the size of national fleets relative to tons shipped is employed for the developing countries.

The new regression thus appends oil prices, container penetration, size of national fleets, and route density to the basic specification from equation 2. Because of comparability problems over time with available containerization data, the sample is split into four sets: 1974-1983 (all countries), 1978-1998 (developing countries only), 1990-1998 (all countries), and 1974-1998 (all countries, no containerization data).

[results]

III. Air Transport

Cost data for air transport are more sparsely reported than for ocean transport. I rely on three 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 contain rich overviews of air cargo freight rates (price per kg for shipment between two cities) for air travel markets around the world. The third source is US customs data on imports entering via air.

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. To provide crude measures of price per output unit, I report average revenue per ton-km as well as a measure of average revenue that adjusts for distance shipped. The latter calculation assumes a cost technology for air shipping given by

$$C = a_t (ton)(km)^{\beta}$$

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. WATS data indicates a rapid rise in mean distance shipped over time, and so average revenue must be adjusted accordingly. Details on the calculation and the relevant elasticity are provided in the appendix.

The numbers show rapid declines in average revenues in the 1950s, 60s, and 80s, with slow declines in the 90s and increases in the 1970s. Comparing the simple average to the adjusted average revenue series shows that the distance adjustment slows the rate of decline moderately.

The ICAO *Survey* provides a more detailed source of data on air cargo rates, albeit a much shorter time series. This evidence is used to evaluate changes in the level of air freight rates, as well as changes in the structure of rates over time. 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]

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.[41] I deflate this series using the US GDP deflator, and an index of air-shipped traded goods prices

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[40] Regression R2 of 0.8 to 0.9 are common.

expressed in terms of price per kg shipped. The latter is used as the time series of prices in air-shipped goods may differ substantially from the overall import series, and the series can be constructed in a way that allows a precise calculation of changes in the ad-valorem freight rates. (Multiplying the cargo rate ($/kg) by the weight-value ratio of a good immediately yields the ad-valorem rate.)

In Table 5, I report annualized rates of change in air freight rates for each route group between 1973 and 1993. The first two columns report changes in the constant dollar price per kg for air shipping, split into the 1973-1980 and 1980-1993 periods. Pooling data from all routes, prices increase 0.73 percent annually until 1980, then decline 2.73 percent annually until 1993. This pattern is reflected in most of the routes – prices increase prior to 1980 for all routes except North and Mid-Pacific; prices decline after 1980 on all routes except local Central America. The extent of price declines varies substantially over routes, with longer routes and those involving North America showing the largest drops. The timing of the rate reduction coincides well with the *WATS* data, which show little price change in the 1970s and rapid declines in the 1980s. Changes in ad-valorem rates are reported in the third and fourth columns. Interestingly, these declines are much larger than price per kg freight rates, with most of the declines concentrated in the 1973-1980 period. The difference between this and the price per kg series can be explained by substantial real increases in the price per kg of predominantly air shipped goods (or, alternatively, miniaturization), most of which were concentrated in the 1970s.[42]

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.

Finally, US trade data by transport mode can be analyzed for air shipping in a manner similar to that from the previous section. Results of estimating equation (2) on air shipments are reported in Table 3. Again, declining distance coefficients characterize the fare structure. The

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[41] 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.

[42] 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.

overall effect on rates at distances of 1-,5-, and 9000 km are pictured in Figure 5. For short routes rates are roughly constant, while rates have declined rapidly on longer routes.

V. Quantities

The price data offered to this point exhibit two basic patterns: liner rates increase relative to tramps until the late 1980s, then fall; air rates fall continuously relative to ocean rates. In this section I employ data on quantities by transport mode as a check on the price data. In addition, quantity data provide indirect evidence on relative prices for ocean and overland shipping.

Figure 6 reports prices and quantities for liners versus tramp ocean shipping. The quantity data are trade values for liner relative to nonliner ocean shipping in US trade (exports and imports), taken from the US Maritime Administration’s annual report, *MARAD*, various years. The price data are relative movement in the liner and voyage tramp indices. Both series are expressed in logs. The price and quantity series move inversely, with liner shares declining as prices rise through the 1960s and 1970s, then rising as liner rates fall, and falling again in the last few years of data. Note that liner shares begin to increase prior to relative price declines of the late 1980s. This may be due to the changing composition of trade. Recall from Table 1 that the share of bulk commodities in trade has fallen dramatically over the relevant period. The majority of trade growth has occurred in manufactures that are rarely shipped via tramp.

One of the most important post-war changes in international transport has been the growth in air freight. Three sources of price x quantity data underscore this point. First, Figure X plots prices and quantities for air versus ocean shipping worldwide. Quantity data are expressed in terms of ton-miles of air shipping (taken from IATA, *World Air Transport Statistics*, various years) relative to ton-miles of non-bulk ocean cargo (taken from UNCTAD, *Review of Maritime Transport*, various years). Price data, as discussed in Section 3 and 4, are average revenue per ton-mile for air shipping relative to the liner price index discussed in section. Price and quantity series are normalized to 100 in 1980. These data show that the rapid relative price declines for air transport are reflected in rapid growth in quantities transported via air.

Second, air transport is concentrated in relatively few places. In 1997, tonnage moved on international routes including North America (primarily the US) constituted 40 percent of all international movements. North American international and domestic air shipments comprise 53 percent of the world total.[43] This gibes well with price data from Table 5 showing the largest declines in air shipping price occurring on North American routes.

Third, Table 2 indicates rapid growth in the value of air shipped trade for the US. US trade data allow a careful examination of quantity substitution between air and ocean transport in response to price movements, controlling for commodity and route composition. Prices are given by the ad-valorem freight rate for air and for ocean shipping for an exporter j (all countries), in commodity k (5 digit SITC), at time t (1974-1998). Quantity data are the value shares of air and ocean modes, jkt. This allows estimation of relative quantities on relative prices, with commodity and exporter effects as controls. To control for heterogeneity within a commodity group, the weight-value ratio for trade via air relative to ocean shipping is also included. (A high ratio implies that air shipped goods have weight-value ratio close to ocean shipped goods, implying more substitutability within the commodity group.) The resulting estimate is

$$\ln\left(\frac{V^{air}}{V^{ocean}}\right)_{jkt} = -0.82\ln\left(\frac{f^{air}}{f^{ocean}}\right)_{jkt} + 0.25\ln\left(\frac{(w/v)^{air}}{(w/v)^{ocean}}\right)$$

The elasticity of quantity change with respect to price change is close to one. This indicates that the substitution toward air transport is a clear function of relative price movements.

Data on the costs of inland transport are extremely difficult to obtain, except on a case study basis. As detailed in Section 2, the few available studies typically find inland transport charges to be the largest portion of international shipping expenses. Clearly then, one would like some assessment of the costs of overland transport.

Two pieces of indirect evidence are available. Liner freight rates include port costs, while the other series (tramp shipping, customs trade data) do not. Relative movements in these rates as discussed above may reveal, crudely, movements 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

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[43] IATA, *World Air Transport Statistics*.

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".[44] To characterize ocean versus land shipping I plot the following statistic in Figure X.

$$XD = \frac{\sum_{jkpt} \left(\frac{\text{actual distance}}{\text{minimum distance}} \right)_{jkpt} \cdot (\text{shipment value})_{jkpt}}{\sum_{jkpt} (\text{shipment value})_{jkpt}}$$

where a shipment only enters the numerator if the shipper's minimum ocean distance port is on an entirely different coast than the port actually employed. Figure 4 shows that excess distance rises from 1969-1979 (indicating substitution toward ocean transport) then falls. This graph can be reconciled with two interesting technological/institutional facts. First, regression evidence from Section 3 indicates that containerization lowers the elasticity of ocean freight costs with respect to distance shipped. This leads to an increase in the ocean leg of transport in the 1969-1979 period. Second, in the 1979-1998 period, regulatory reform of trucking and rail shipments lowers the cost of overland transport, leading to substitution towards overland transport. This explaination can be confirmed by again restricting the sample to countries with very little containerized transport prior to 1980. Recall, section 3 demonstrated that the elasticity of ocean freight rates with respect to distance do not fall until after containerization is introduced. For these countries, excess distance is roughly constant until 1979, at which point ocean legs fall substantially.

This evidence suggests a sizable decline in the cost of overland transport in the wake of deregulation. However, it is important to realize that this does not necessarily imply that

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[44] 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.

shipping costs for international goods have fallen relative to domestic goods. 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.[45]

V. Implications and Extensions

This paper has drawn on an eclectic mix of data to characterize the time series in international transportation costs. To summarize, ocean freight rates have not declined in the post-war era, and have exhibited periods of substantial increases. Notably, prices for liner ocean shipping, which constitute the large majority of world trade, increase slightly from 1952-1970, increase substantially until the mid-1980s, then decline. The overall message of fluctuating, but not declining freight rates is consistent with data on aggregate freight expenditures for New Zealand. The surprising 1970-1985 increases are consistent with cost data and liner price data from other routes, and systematic evidence from US customs data.

US customs data further illustrate the role of technological and institutional change in shaping the time series in freight rates. Containerization changes the composition of freight rates – lowering prices of long routes relative to short routes – but does not reduce the overall level of freight rates until the late 1980s. Route density also plays an important role; freight rates drop most on routes where trade has increased most. This may reflect either a competitive intensity effect, or the importance of scale economies in route size. Finally, cargo reservation policies, in which developing countries reserve a substantial share of shipping for national-flag fleets, helps explain differences in rates across countries as well as rising rates through the late 1970s and early 1980s.

In contrast to ocean shipping, the price of air transport has fallen dramatically over time, though declines are smaller or nonexistent through the 1970s. In contrast to ocean shipping, air freight rates have enjoyed steady and sizeable declines. Comparative data indicate that the largest price declines have occurred on longer routes and those involving the US. Finally, modal use varies in a manner consistent with relative price movements. The quantity of trade transported

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[45] A counter argument is that domestic transactions have the option to locate internally so as to minimize these costs,

through liner shipping falls relative to tramp shipping, then rises, moving inversely to prices for these modes. Similarly, the share of trade transported via air rises sharply as air prices fall relative to ocean transport prices, with the largest growth in air transport occurring where relative prices have fallen the most. And, indirect evidence for the US suggests strong substitution toward land-based rather than ocean-based transport.

Three challenges remain. The first challenge is identifying the role that transportation plays in trade growth and international integration more broadly. Figure 8 shows the growth of world trade relative to output. Trade to output rises steadily throughout the post-war era except during a period from the early 1970s to mid 1980s. This is precisely the period when ocean transport costs rose rapidly and air transport costs remained constant. The strong implication is that rising transportation costs in this period arrested other forces for integration such as tariff reductions. But this is overly simple. A more nuanced analysis of the importance of transport is needed. 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.

This leads us to a second challenge. The data provided here implicitly assume that transportation services are of homogeneous quality over time, and this will likely concern many readers. The difficulty lies in identifying the sources of quality change and their effects. There have undoubtedly been important technological changes in shipping yet it is unclear whether these yield better quality transport services to importers that are not already being measured. More efficient ships ought to yield lower shipping prices; navigational aids that limit accidents should reduce insurance premiums.

One obvious quality improvement is speed. This is manifest in the switch to air transport as well as in substantially increased ship speed for containerships. A narrow view of the value of time might focus primarily on inventory-holding costs, and these are likely to be quite small. 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. A simple 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.

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and so may less intensively demand domestic transport.

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

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Figure 1 -- Aggregate Freight Expenditures: US and New Zealand

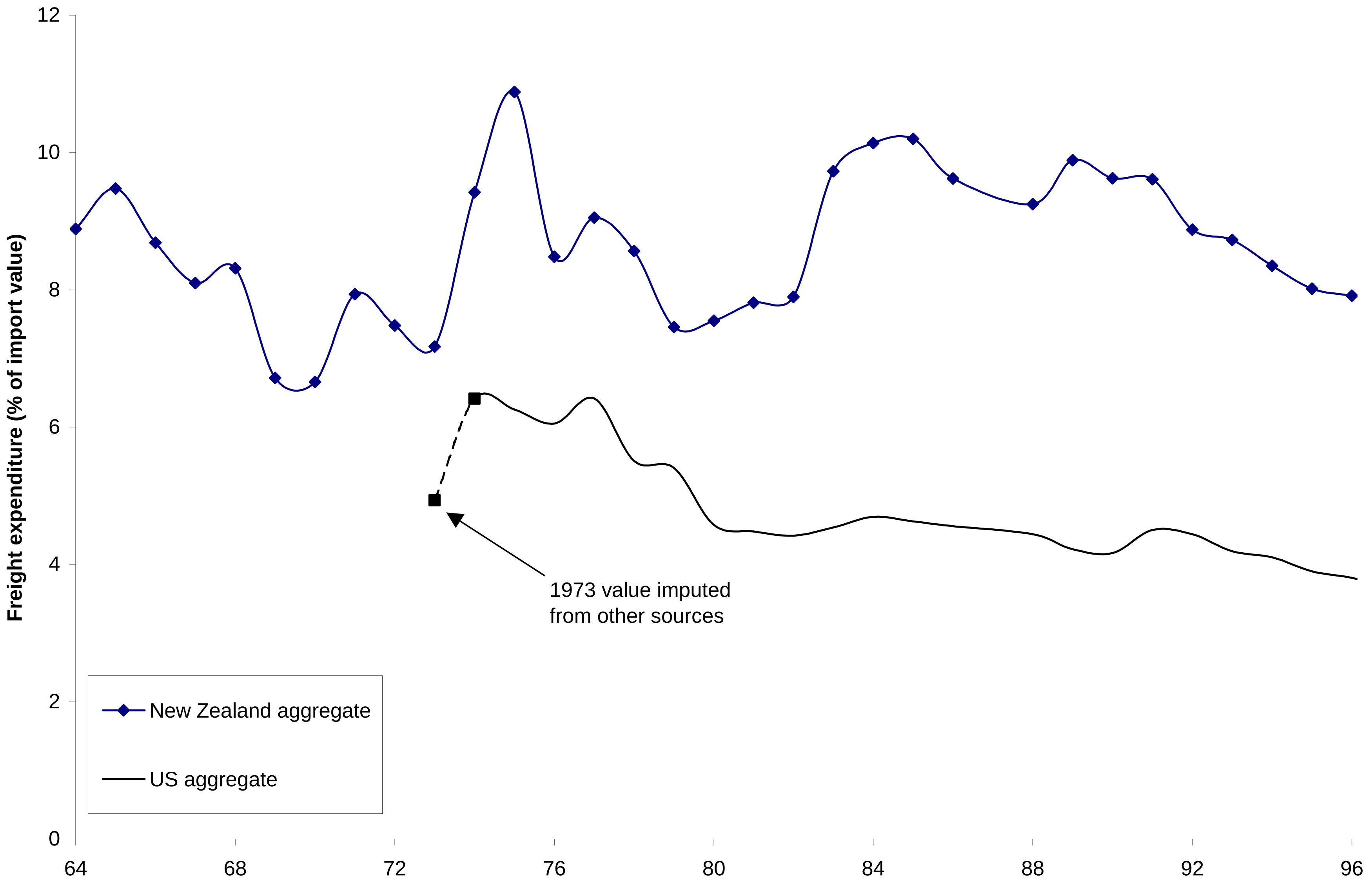


Figure 2 -- Liner Price Index

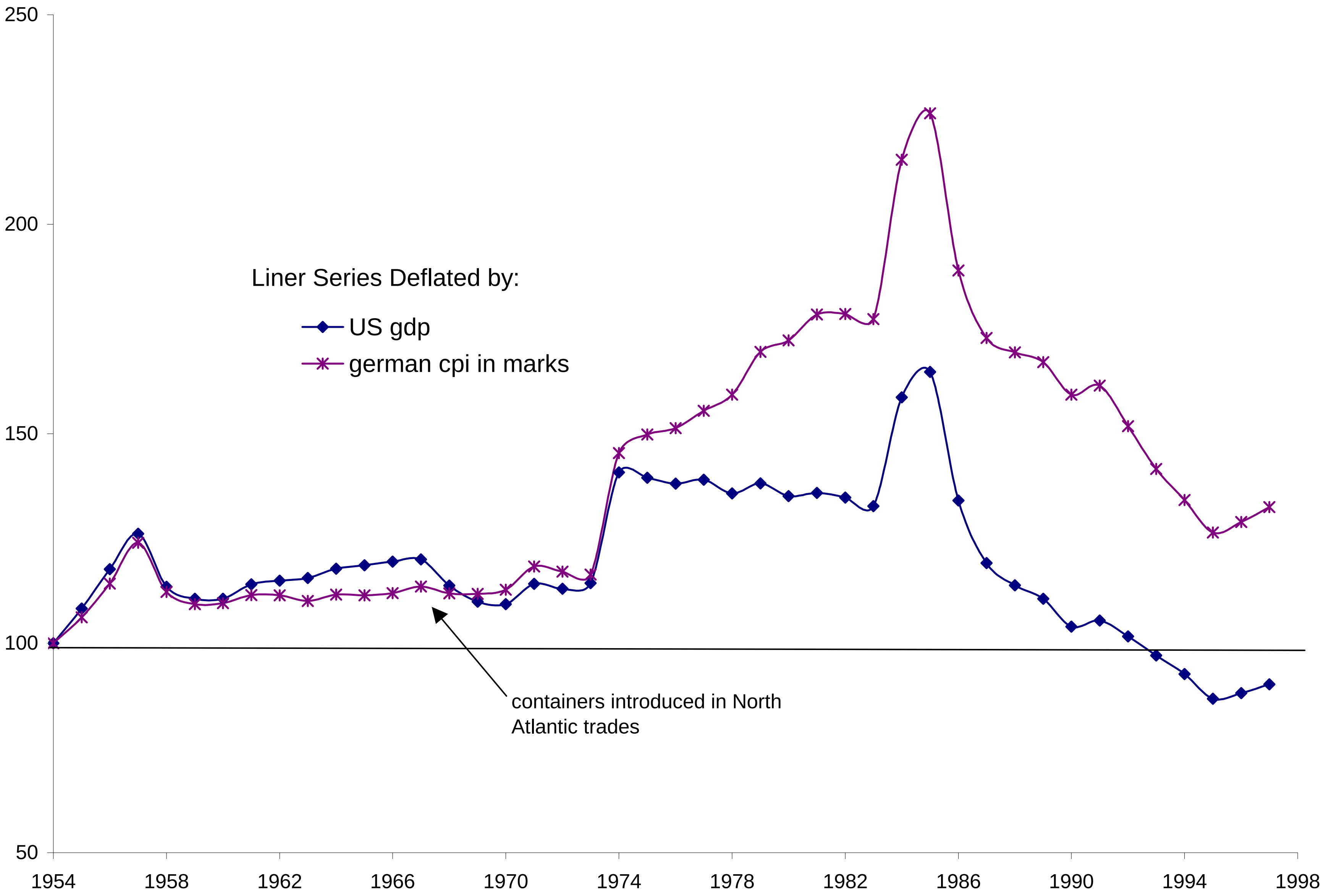
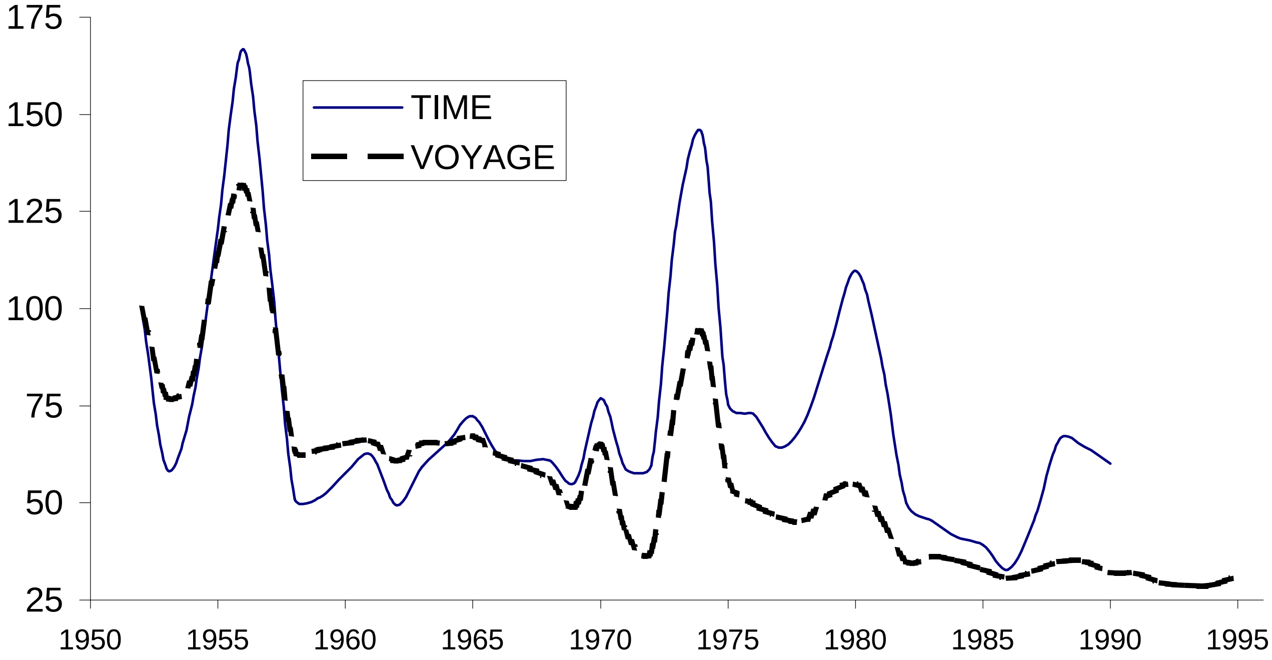
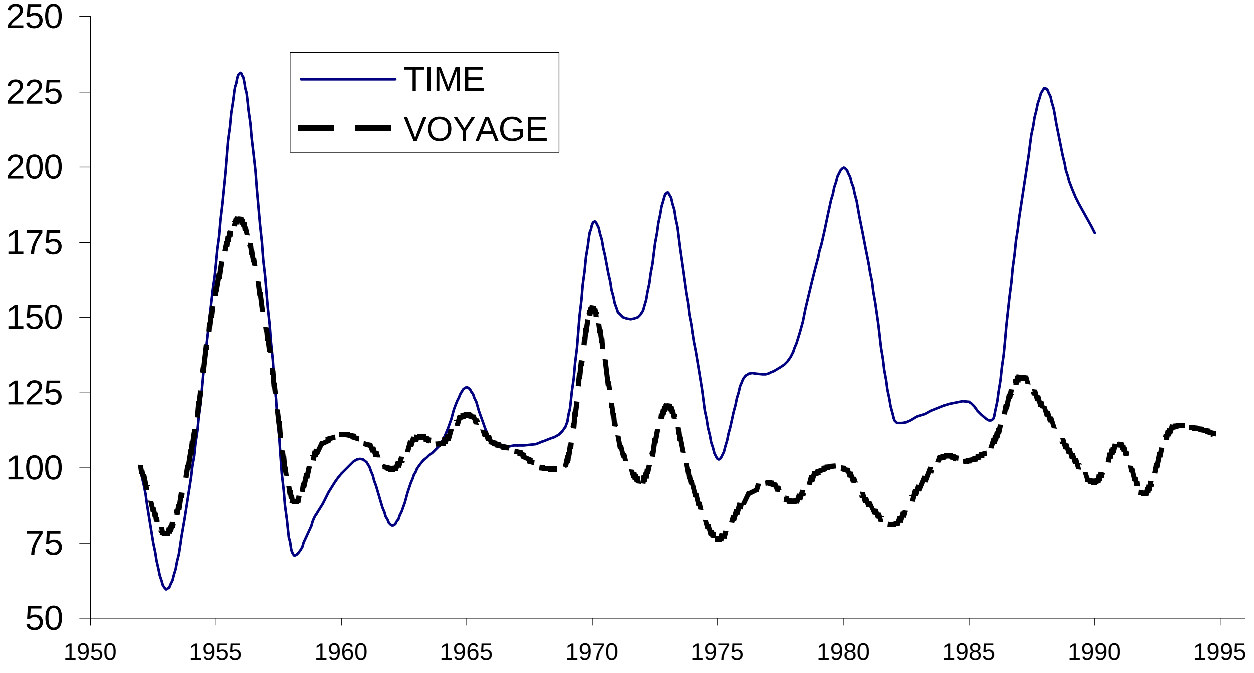


Figure 3 -- Tramp Shipping Rates



GDP deflator

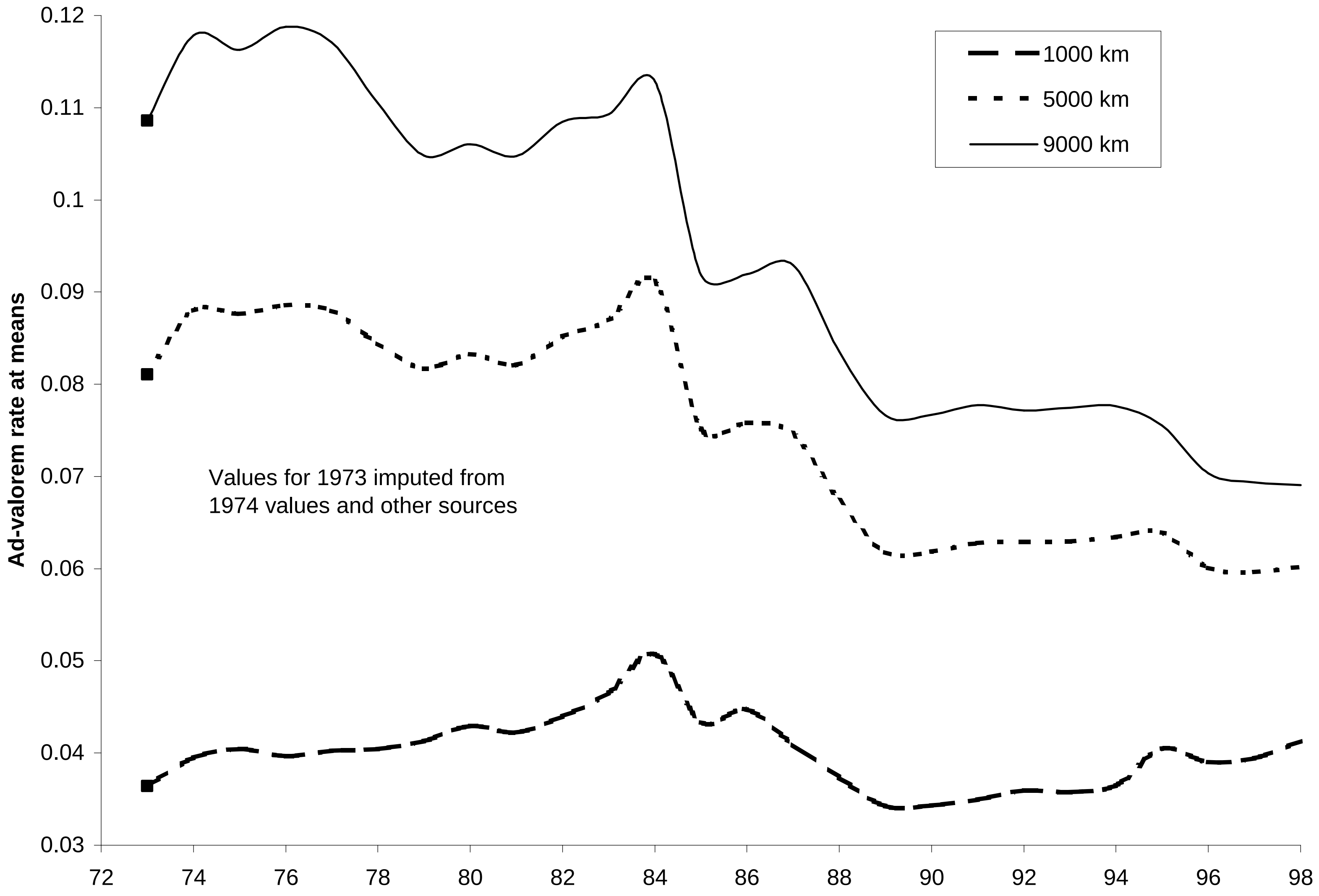


Commodity price deflator

Figure 4 -- Fitted Time Series: Ocean Freight Rates

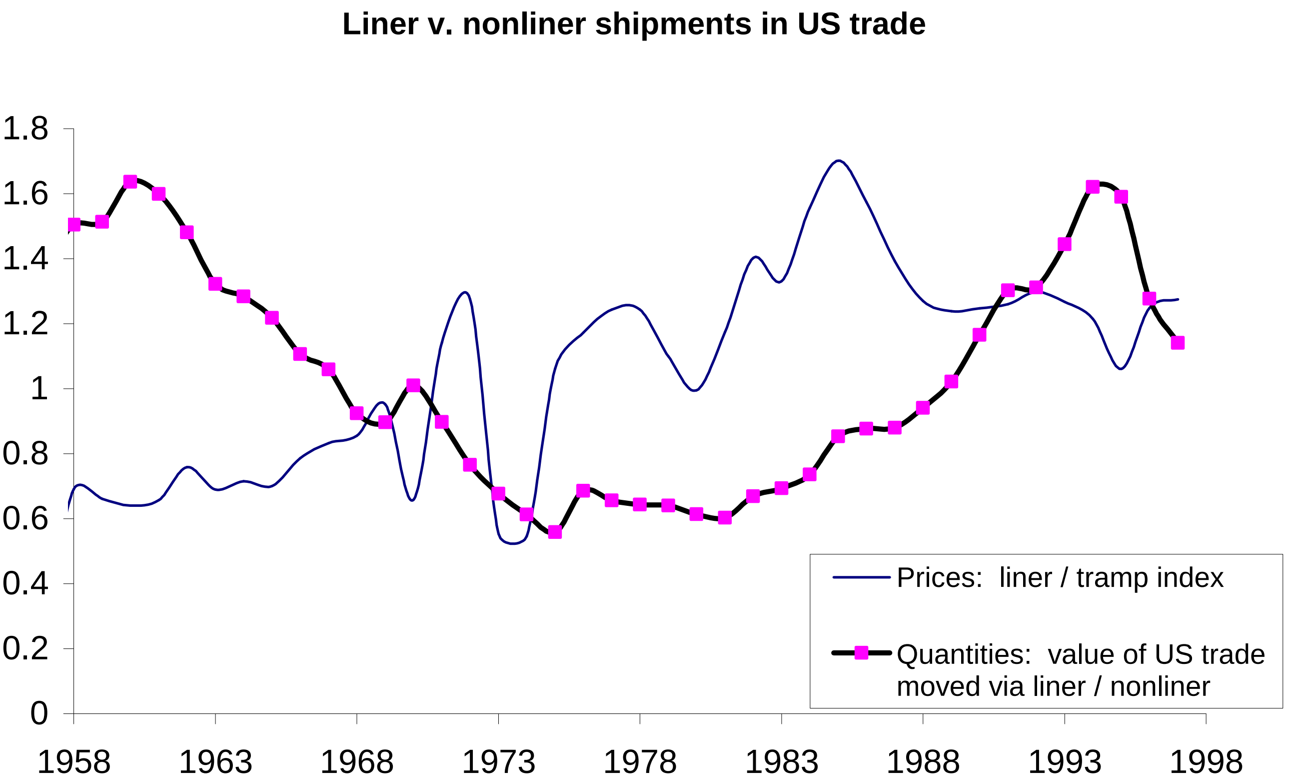
Values for 1970, 1973 imputed from 1974 values and other sources

Figure 5 -- Fitted Time Series: Air Freight Rates



Values for 1973 imputed from
1974 values and other sources

Figure 6 -- Prices and Quantities



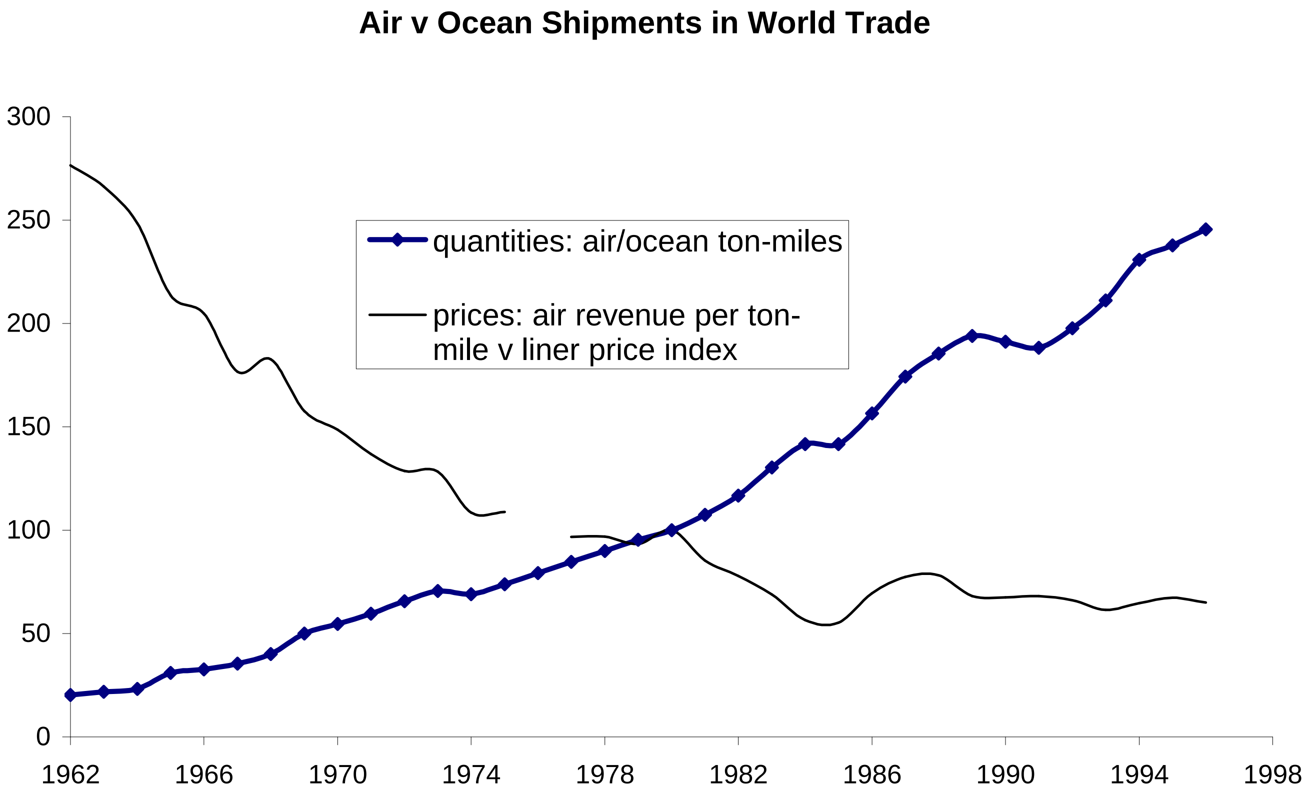


Figure 7 – Ocean v. Land Distance Substitution
US Trade, 1969-1996

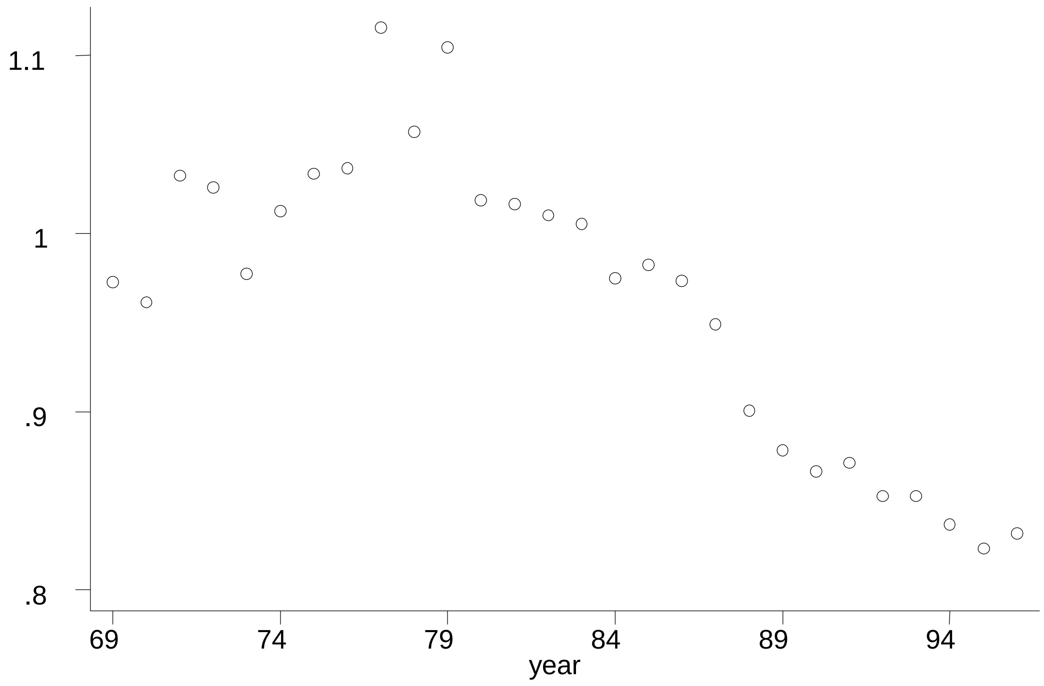


Chart shows excess ocean distance traveled to avoid land shipping

Figure 7 -- World Trade/Output Growth 1950-1995

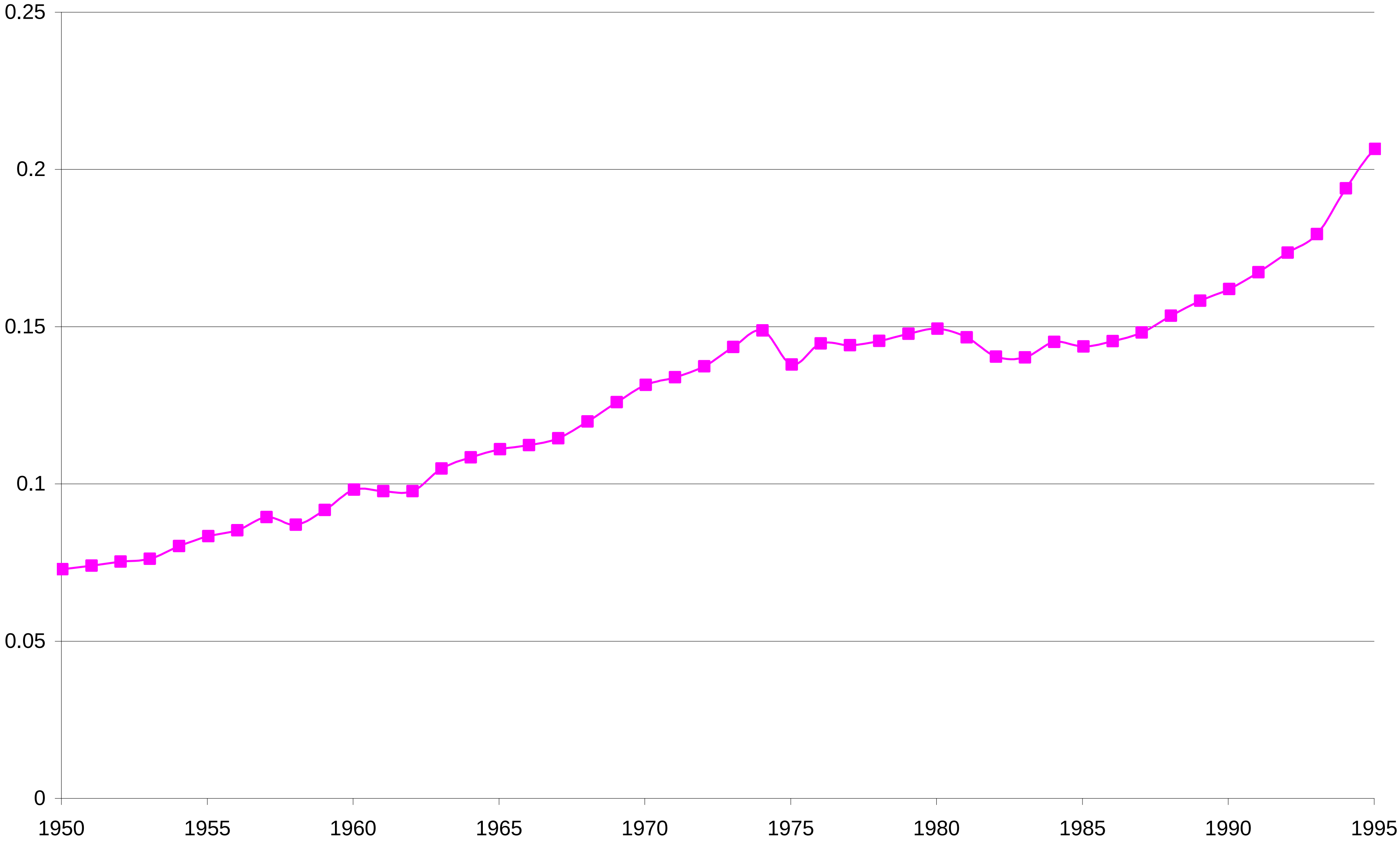


Table 1: Composition of Trade Growth

SITC	Commodity	Value Share in US Imports 1969	1995	% Change 1969-95	Transportability (1995) (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 Equ	26.8	46.2	72.2	0.06	2.25
8	Misc Manufactures	10.5	16.5	57.5	0.09	4.37

Table 2: US Trade by Transport Mode

(% of value)

	Imports			Exports		
year	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
1998	45.5	24.7	29.7			

Sources: US Census, "US Imports", Statistical Abstract of the US

Table 3 --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

Table 4 -- World-Wide Air Freight Average Revenues

(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, author's calculations

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)

	Shipping price *per kg* *(1990$)*		Ad-valorem Air Freight Rate		Distance Premium
years	1973-80	1980-93	1973-80	1980-93	1973-93
All Routes	0.73	-2.73	-7.41	-1.30	-0.66
Developed Nation Routes					
North Atlantic	0.75	-3.79	-7.39	-2.38	-1.37
Mid Atlantic	3.17	-3.57	-5.17	-2.15	-1.72
S Atlantic	5.47	-4.12	-4.28	-2.72	1.23
North and Mid Pacific	-3.69	-1.68	-11.48	-0.24	-0.42
South Pacific	-2.75	-1.19	-10.62	0.26	-0.41
Developing Nation Routes					
North to Central America	4.80	-0.93	-3.67	0.52	-0.57
North and Central America to South America	2.06	-1.41	-6.19	-1.28	-1.98
Europe to Middle East	4.52	-3.23	-3.93	-1.81	0.47
Europe and ME to Africa	1.56	-2.54	-6.65	-1.11	-2.38
Europe/ME/Africa to Asia/Pacific	3.04	-2.98	-5.29	-1.56	0.86
Local Routes					
Local Asia/Pacific	0.62	-1.73	-8.68	-0.29	-1.84
Local North America	1.35	-1.94	-6.84	-0.50	-1.09
Local Europe	4.22	-2.83	-4.20	-1.41	-1.38
Local Central America		0.76		2.23	-1.11
Local South America	2.25	-2.45	-6.01	-1.02	0.58
Local Middle East	1.64	-1.67	-6.58	-0.23	-0.24
Local Africa	4.66	-2.63	-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.

Appendix I: Details on Calculations

III. Air Transport

Calculation of adjusted average revenue from World Air Transport Statistics.

WATS reports total revenue and total ton miles. Assume a shipping technology of

$$C = a_t(ton)(km)^{\beta}$$

where at is a time specific cost shifter. If beta =1, at = revenue/ton-km. The ICAO *Survey*, and US customs data reported by transport mode, can be used to estimate the relevant elasticity. The *Survey* reports regressions of (log) cargo rate on the (log) air distance between cities world-wide. Using world-wide data, the elasticity of costs per kg with respect to distance is .81 in the earliest available year, 1973. Estimates from US trade data, reported in table X, reveal an elasticity of 0.5 in 1974. This lower estimate matches Survey estimates on North American routes.

I calculate mean distance shipped in each year by dividing ton-km shipped by tons. The time specific shifter is then estimated as

At = revenue / tons * km^beta.

Estimates using beta=.5 and .81 are employed. 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).

Calculation of price index for air shipped goods

In order to construct an ad-valorem freight rate using cargo rates ($/kg) from the ICAO *Survey*, it is necessary to multiply by some appropriate weight-value goods ratio. 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, multiplying the *Survey* fares by the aggregate weight-value ratio of 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 using US trade data in 1973.[46] 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.

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[46] 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.

Appendix II: Data

Shipping Indices

The *Norwegian Shipping News (NSN)* compiles index numbers for both tramp time and tramp voyage charters. The tramp time charter index is a weighted index number of the cost of employing entire vessels of varying size and speed for periods less than nine months. Coverage of charters is worldwide, and the use of the ships (i.e. which goods they will transport) is ignored. 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 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 NSN series are not the only available tramp series -- UNCTAD's *Review of Maritime Transport* and the OECD's *Maritime Transport* report a large number of tramp shipping indices over time. For this paper only the NSN series are reported as they provides the longest continuous coverage of rates. Other series differ somewhat in terms of weights and coverage of the index number. However, the basic message of Figure 2 holds regardless of which series is chosen, and the various series tightly covary. (To see this, compare the NSN indices with those provided by the UK Chamber of Shipping. The correlation coefficient between voyage charter indices is .87, and the correlation time charter indices is .93 to .95.)

The liner shipping index for Germany is compiled by the German Ministry of Transport. It differs from the NSN 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.

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 III: 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) yearbooks and data tapes, and the *International Financial Statistics* (IFS). All 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 is not the primary purpose of these publications, *DOTS* and *IFS* are sometimes used to this end. 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 the IMF 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). This is potentially quite valuable, as carefully measured transport cost data are available for only a small set of countries in cross-section, and only the US and New Zealand in a lengthy time series. Moreover, as Figure A.1 shows, world-wide cif/fob ratios decline steadily in the post-war era, yielding a time series on transport costs that accords well with conventional wisdom. Unfortunately, quality problems should disqualify these data from use as a measure of transportation costs in even semi-careful studies.

There are three serious problems. First, small discrepancies in the report of the importer or exporter yield large changes in cif/fob ratios. This 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.[47] 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. Similarly, IMF data on the value of trade are quite consistent (though not identical) when drawn from the *IFS*, the *DOTS* yearbook, or the *DOTS* data tapes. However, there appears to be no correlation in cif/fob ratios constructed from these sources.

Second, 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 underlying the IMF reports. Between 1962 and 1983, the data contain reports on aggregate trade flows from both partners for

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[47] 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.

fewer than 40 percent of the bilateral pairings.[48] When data are missing, the IMF constructs the cif/fob ratio using only one report. The documentation in the *DOTS* yearbook 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. This adjustment is applied to all country pairs and all time periods for which paired data are not available.

This imputation pattern may explain the otherwise interesting decline in aggregate cif/fob reported in Figure A.1. Actual cif/fob ratios for developing country trade are generally higher than the 10% imputation factor because much of this trade takes place in expensively shipped bulk commodities. The quality of export data is steadily 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.

Third, the value of trade reported by importers and exporters may differ for many reasons other than shipping costs. This means that cif/fob ratios constructed from matched country reports may not be useful as a measure of transport costs even when both partners report data and the IMF has not tampered with the ratio. Yeats (1978) compares matched country cif/fob ratios from the *COMTRADE* data to US Census data in which shippers report both the fob value of trade and explicit expenditures on transport. Exploring cross-sectional variation over countries and commodities in 1974, he finds the Census and *COMTRADE* series are basically orthogonal.

I employ a similar technique in order to relate time-series variation in IMF cif/fob ratios to accurate measures of shipping costs as reported in US Census and New Zealand data. The goal is to determine whether the IMF data might provide useful, if noisy, measures of the time series in transport costs when better data are unavailable. As researchers may find themselves employing the *IFS* or the *DOTS* tapes, and as these sources do not agree, I report results for each. (The *DOTS* yearbook data are not analyzed as they vary so markedly depending on which edition of the yearbook is consulted.)

The *IFS* reports a single cif/fob ratio for each importer in each year (1948-1997) that is aggregated over all commodities and partner countries. I compare these to the national data sources beginning in the first year that national sources report both cif and fob valued trade (1974 in the US, 1963 in New Zealand). The *IFS* cif/fob ratio closely matches US Census data, both in level and time series variation. With the exception of a few anomalous years in the early 1980s, the *IFS* data also matches New Zealand's national sources quite closely. Apart from the US and New Zealand, cursory inspection shows that data taken from the *IFS* are not useful for examining time series variation in importers' cif/fob ratios. It appears that a single cif/fob ratio, generally around 1.10, is chosen for each importer and is not changed over time. (Around half of all the time series observations on cif/fob for an importer equal that country's modal value exactly.) One suspects that the match between the *IFS* and national source data comes from discarding the usual methodology and using the accurate US and New Zealand data to correct poorly

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[48] Dropping those bilateral pairs with an implied negative transport cost (cif/fob ratios less than one), or with transport costs exceeding twice the value of the goods shipped, the data contain usable reports from both partners for fewer than 25 percent of pairings. The problem is much worse for commodity level data, which casts doubt on the accuracy of the aggregate figures.

measured exporter (fob) reports. Notably in both cases, the *IFS* data displays a discrete jump from the previous level and trend in the year that national data become available.

The *DOTS* tapes allow a more robust examination of the validity of IMF cif/fob ratios for the US and New Zealand. I compare the cif/fob ratio for exporter j at time t as reported in *DOTS* and in national sources. This is done first with a simple regression of the IMF data on the national data, then a regression that includes exporter fixed effects.

$$\left(\frac{cif_{jt}}{fob_{jt}}\right)^{imf} = a + b\left(\frac{cif_{jt}}{fob_{jt}}\right)^{national} + \varepsilon_{jt} \quad \text{and} \qquad \left(\frac{cif_{jt}}{fob_{jt}}\right)^{imf} = a + b\left(\frac{cif_{jt}}{fob_{jt}}\right)^{national} + \eta_j + e_{jt}$$

Since the IMF data are based in part on noisy exporter reports, fixed effects are included to allow systematic reporting errors that are exporter specific. To be comfortable employing the DOTS data, one would like coefficients equal to one, with little unexplained variation.

This analysis requires first "cleaning" the IMF data to remove nonsensical observations. For approximately half of the exporter x time observations *DOTS* reports a cif/fob ratio that implies negative transport costs, or costs exceeding twice the value of the traded goods. Without dropping these, the New Zealand data are orthogonal to the IMF source data and the US data are negatively correlated with the IMF data.

After substantially reducing the data to include only plausible observations, I find that the IMF data are positively related to New Zealand data. However, the coefficient is closer to zero than to one, and variation in actual transport costs explains only a very small fraction (R2=.04) in observed IMF cif/fob ratios. Employing exporter fixed effects increases the fraction of variation explained, but lowers the estimated coefficient. That is, the IMF data are poor proxies for cross-sectional variation in transport costs, but poorer still when restricted to explaining within, or time series variation. The news for US data is even worse – IMF and national source data are completely orthogonal with or without fixed effects. On the basis of the US and New Zealand data it appears that the IMF data contain no information about the actual time series in transport costs.

	IMF Direction of Trade Statistics versus National Sources			
	New Zealand (1963-1997)		United States (1974-1997)	
Dep var: cif/fob from IMF DOTS	OLS	Exporter fixed effects	OLS	Exporter fixed effects
Constant	.83 (.06)	1.32 (.10)	1.25 (.16)	1.30 (.19)
National cif/fob	.43 (.05)	.19 (.07)	.02 (.15)	-.02 (.17)
R2	.04	.25	0.00	.25
obs	1632	1463	2194	2171

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)

Table A2 -- 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

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