

Relative Transport Price Movements and World Trade

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Abstract

This paper provides the first direct measurement of the impact of relative transport price shocks on world trade flows. Previous work examined the impact of this shock on US imports over the 1990s. To show that the results generalize to both a longer time period and world trade, I propose a new measure for air suitability. This measure is available for most disaggregated trade datasets, which will allow similar analyses to be performed on firm level data and in other contexts. Utilizing it, I show that within an industry trade in varieties that are more suitable for air transport grew faster from 1975 to 2005, and this growth bonus increased with the distance of the route. This period accords with a near monotonic decline in the relative price of air to ocean transport strongly indicating that the effect is driven by the declining price of air transport. The effect is both statistically and economically significant at the variety level, but has less significance once aggregated to the country level.

1 Introduction

From 1960 to 2000 the price of air transport fell relative to the price of ocean transport by 71-88%¹, yet remarkably little is known about what impact this change will have on trade flows. Initial examinations of the data, like Choate (2008), were restricted to the recent history of American imports due to the scarcity of explicit measures of transport mode. This paper directly addresses that shortcoming by proposing a measure of air suitability that will allow the economist to examine the impact of the relative transport price shock on world trade. Using this measure of air suitability, this paper provides the first direct estimates of the impact of declining relative air transport prices

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¹All long run transport price figures come from Hummels (2007).

on world trade flows. Following the methodology of Choate (2008), declining relative transport prices are assumed to lead to intra-industry shifts in trade growth. Goods that are more suitable for air shipment should experience faster trade growth than goods which are less suitable for such transport, and this effect should increase with distance. So long as industries are narrowly-defined, this effect is consistent with expectations of decreasing transport prices and will not be driven by differential changes in demand across industries. Further, since the growth effect increases with distance, the competing hypothesis of an increased demand for higher quality goods is ruled out.

Estimating the impact of the relative transport price shock requires either a measure of air transport utilization or suitability for air transport. Data on the former is available only for very restrictive datasets, such as US imports over the 1990s. This paper proposes a measure for the latter and shows that it captures similar trade dynamics as actual air transport usage data. This measure, the logged ratio of value to weight, is available in almost all disaggregated trade datasets, drastically increasing the scope of questions and contexts in which the effects of changing relative transport prices may be examined.

Previous work demonstrated that air shipped goods tend to be both more valuable and lighter than surface shipped goods². Air shipped goods are lighter than their surface shipped counterparts because the price of air transport rises rapidly with weight³. They tend to be more valuable than surface shipped goods because the reduction in inventory costs brought about by the reduction in transport time increases with the value of the good. The *ad valorem* cost of transport for valuable goods is also lower, which allows them to absorb the higher costs of air shipment.

In addition to growing with the value and the inverse weight of the goods, the benefits of air transport increase with the distance shipped. The time of transit avoided increases with the route length, and uncertainties connected to delivery time and demand are reduced more on longer routes for similar reasons. These, and other, advantages drive the uptake of air transport as its costs fall relative to other means of transportation, and they point to methods for identifying the

²Throughout this paper a good will refer to a type of product while a variety will refer to the combination of that product and a bilateral trade route.

³It also rises quickly with the bulkiness of the good, but as there is limited data on physical volumes of goods shipped, this effect is ignored.

effects of such relative price changes. Choate (2008) used these stylized facts to show that US imports of goods unsuitable for air transport grew faster from nearby countries while imports of goods suitable for air transport grew faster on longer routes. Since developed countries produce higher quality goods that are more suitable for air transport, this meant that imports from distant, developed countries grew faster than imports from distant, developing countries.

This paper finds similar results for world trade. Goods suitable for air transport grew faster on longer routes, while goods suitable for surface transport grow faster on shorter routes. This latter effect is less pronounced for world trade than it was for US imports, but evidence of it remains. These results also generalize to the longer time period 1965-2005. Breaking this sample into 5-year periods, I find significant variation in the predicted growth benefits for goods suitable for air shipment over time. Prior to 1975, there is insignificant difference between the growth rates of air suitable goods and those not suitable. From then until 2000 the growth bonus for air suitable goods remained large as relative transport prices fell by almost 10% every five years. From 2000 onwards, as the relative price shift reduced and absolute prices for air and ocean transport increased, the growth benefits of air transport slackened.

While displaying significant variation across time, there is no similar dispersion in impact across countries. For nearly two-thirds of the countries in the sample, the proportion of varieties traded that benefitted from the relative price decline lay between 45-55% of the total number of varieties traded. Likewise, changes in the trade weighted average distance of bilateral routes fell for most countries, indicating that even though air transport allowed for trade on longer routes, an increasing proportion of trade occurs within regions. This implies that while the relative decrease in air transport prices had significant effect on variety-level flows, it had minimal effect on country-level trade patterns. The related question of firm level impacts is left unexamined, but a country would be well served to maintain flexibility in product markets and invest in transport infrastructure to smooth any transport shocks. By ensuring that firms can respond to such shocks, which cannot be forecast, a country prepares itself to take advantage of the opportunities presented by the relative prices. To reach these conclusions, this paper proceeds by discussing the literature and methodology that will be used in the next section. Section 3 presents the initial

results, and Section 4 concludes.

2 Literature Review and Methodology

The first paper to identify the magnitude of the relative decline in air to ocean transport prices was Hummels (2007). Hummels estimated that the cost of air shipment fell by 71-88% relative to ocean transport from 1960-2000⁴. Harrigan (2006) provides a framework in which to think about the effects of this shock. In his model firms choose between ocean and air transport. Air transport is more expensive, but goods delivered via this mode receive a premium in the market. This premium could arise from reduced delivery uncertainties (Harrigan and Venables 2006), demand uncertainties (Harrigan and Evans 2005), or spoilage and inventory costs of transport. Hummels (2001) provides evidence that this air premium exists by showing that manufacturing firms are willing to pay 0.6-0.8% *ad valorem* per avoided day of shipment time. Given that air shipment from China can avoid 20 or more days of transit time, this air premium can be substantial.

Harrigan's model produces two predictions for the impact of decreasing relative air transport prices. First, goods already shipped by air receive a positive cost shock and gain market share. This is equivalent to faster trade growth for those goods relative to surface shipped versions. Since the modal choice is related to the route length, this is also equivalent to faster trade growth for such varieties on longer routes. Second, the increase in market share for the distant air shipped varieties drives the producers of similar goods on shorter routes to reduce labor. The reduction in labor demand leads to labor slackness and lowers wages in the nearer country. The lower wages increase the comparative advantage of surface shipped goods producers from this country. Thus surface shipped goods gain market share, or experience faster trade growth, on the shorter routes.

These predictions are clear and intuitive in a three-country model, but it is unclear how well they will generalize to a multi-country setting. Since each country trades with partners of varying distances, the wage effect described above may not occur. A country that loses out in trade of

⁴The range arises from different ways of calculating the ocean price index. The main story of increasingly cheaper air transport holds across all estimates though.

an air shipped good with one partner may merely increase trade of that same good with a more distant partner. Likewise the model differs from reality by saying all countries produce all traded goods in an Eaton-Kortum framework. In reality countries trade in only a subset of all goods and then with only a subset of all partners. Further, the goods produced vary widely in quality across countries in a way they do not in the model. It is this variation in quality that is used to capture variation in the suitability of a variety for air transport. Harrigan's model predicts that air shipped goods will benefit the most from a decrease in the price of air transport. However, as mode of transport is not available for world trade data, I will use the ratio of value to weight in its place. Harrigan shows that both this figure, which can be thought of as a measure of quality, and the use of air transport increases with route length. Choate (2008) shows directly that the use of air transport is increasing in the logged value to weight ratio. It also shows that Harrigan's predictions hold for US imports during the 1990s. Within an industry trade in heavier, or lower quality, varieties grew faster from countries within the Caribbean Basin. The opposite is true for trade in varieties suitable for air shipment. These grew faster from more distant countries.

Intra-industry trade patterns were analyzed for three reasons: the results are easier to interpret, the substitutability assumption is more intuitive, and deviations in the value to weight ratio within an industry are more likely to be correlated with quality than deviations would be across industries. As an example, the decrease in air transport prices is not expected to lead to consumers substituting sweaters for oil. Certainly this could happen as a second order effect if the prices of other goods fall. A more straightforward story is that consumers will switch from surface shipped to air shipped sweaters, and that these will tend to have higher value to weight ratios. Such an approach is easier to interpret because more air suitable goods are easily recognized across industries. Using industry fixed effects would work in a similar manner, and though not presented here, the results of using the raw value to weight ratio are similar to those presented below and are available from the author upon request. To analyze intra-industry effects, the value to weight ratio removes the 2-digit industry mean.

$$\ln(\hat{vpw}_{ijk}) = \ln(vpw_{ijk}) - \frac{1}{n} \sum_{k_4 \in k_2} \ln(vpw_{ijk})$$

Here and elsewhere in this paper, a hat denotes that the 2-digit industry mean has been subtracted from the variable in question⁵ and vpw denotes the value to weight ratio. The mean is calculated in the normal manner on the logged variable to ensure that the average of the constructed variable is 0.

With a measure of intra-industry value to weight deviations, the effects of decreasing relative air transport prices can be estimated via:

$$\Delta_m T_{ijkt} = \alpha_{ijt} + \alpha_k + \beta_1 \ln(\widehat{vpw}_{ijkt}) + \beta_2 \ln(\widehat{vpw}_{ijkt}) * \ln(\text{distance})_{ij} + \beta_3 IShare_{ijkt} + \epsilon_{ijkt} \quad (1)$$

This regression mirrors the approach of Choate (2008) but makes three alterations so that it may be applied in a more general setting. As in that paper the dependent variable is the bound rate of trade growth for a variety. Bound rates are used to minimize the problem of outliers which can be quite substantial in disaggregated trade data⁶. Time subscripts indicate the initial year in the period over which growth is calculated, so the regression estimates subsequent trade growth as driven by initial period trade patterns. Since relative transport prices cannot be forecast with accuracy, this approach prevents endogeneity concerns related to switching transport mode.

As mentioned earlier, there are three differences between this equation and that in Choate (2008). First, the logged value to weight ratio is used in the place of the share of a variety shipped by air. This latter figure is available from the US Census Bureau's Imports of Merchandise dataset for US imports for the 1990s. To expand beyond that sample, the measure of suitability for air transport must be used instead. In the results section below, I show that this substitution does not alter the results. Second, Choate (2008) included controls for changing freight and tariff rates which are not available in the broader dataset. Instead a measure of the size of trade in a variety is included as a control. The $IShare$ variable measures the percent of world trade value in a 2-

⁵Choate (2008) looked at deflections within a 4-digit industry, while for data reasons, this paper will look at deflections within a 2-digit industry. The results presented below demonstrate that this change does not significantly alter the findings.

⁶Growth rates in the sample exceed 14 million percent, and using this measure leads to highly spurious results in an effort to minimize the mean squared error for this and other observations. Since large growth rates are associated with small trade flows, this has the effect of weighting less important trade flows more than heavy trade flows.

digit industry accounted for by the variety. This controls for the inverse relationship between size and growth that arises because the initial period value is in the denominator of the dependent variable⁷. Finally, the equation includes both 2-digit industry fixed effects and route fixed effects. These latter are allowed to vary over time to capture the changing nature of bilateral trade relations including bilateral trade agreements or the evolution of country relations.

The value to weight ratio enters the equation by itself and interacted with the length of the route. This allows me to rule out the competing hypothesis of an increased demand for quality goods. There is no reason to expect that the effects of such a demand shock should demonstrate any correlation with the length of the trade route. The route length used is the author's calculation⁸. With the exception of NAFTA countries, the distance is the minimal distance between the capital cities of each country. The NAFTA countries are modeled as having multiple entry points⁹, and the distance between them and other countries is the minimal route length among ports of entry.

The bilateral trade data to estimate this equation comes from the UN's Comtrade database. This dataset contains disaggregated trade data at the 4-digit level for all country pairs from 1965 onwards¹⁰. Prior to estimation the data is cleaned in two ways. First, Industry 33 which includes petroleum products is dropped. This industry is excluded because it groups crude oil with petroleum jelly, products with a wide range of value to weight ratios that we would not assume to have a high degree of substitutability. The results are robust to the inclusion of petroleum products though. The second cleaning step is to remove observations that either lack weight data or have weights of 1. This latter is usually a sign of measurement error, and the former do not have sufficient data for estimation.

This approach has two main limitations. It can only analyze intensive margin trade, and it ignores the question of switching transport modes. Both of these arise due to data. Extensive

⁷An alternate approach would include the logged initial period trade value as a control, but this is collinear with the main variables of interest, so the share approach was used.

⁸Full details of the variable construction may be found in Choate (2008), and the data may be obtained from the author upon request.

⁹Los Angeles, Houston, and New York for the US

¹⁰It actually can go back to 1962, but since this paper will look at growth over 5-year periods, only the data from 1965 on are used.

margin trade observations must be dropped because there are no initial period values to include in the regression for varieties that enter the market. Necessary data is only available for varieties that exit the market, and including only these would bias the estimates downwards. Given both the level of aggregation of the trade data and the use of 5-year time spans in the analysis, excluding the extensive margin does not exclude much trade. A variety that enters in one period, will be included in the analysis in the next period so long as it remains in the traded market. Exiting varieties accounted for less than 10% of trade by value for every initial period with the exception of 1985. Modal switching is ignored because there is insufficient data to address it. All trade data is aggregated to the country level so it is never clear if a change in value to weight ratio of a variety is brought about by product innovation on the firm level, or by the entrance of a new firm. While not shown here, there is no significant relationship between the change in the value to weight ratio and the rate of trade growth.

3 Initial Results

The previous section outlined the method of analysis that will be used throughout this paper. As was shown in Choate (2008), initial period air share usage correlates with subsequent trade growth caused by declining relative air to ocean transport prices. Table 1 compares the results for US import growth over the 1990s using the proportion of a variety shipped by air in the initial period to the results using the initial period value to weight ratio. As expected, this measure of suitability for air transport captures the same dynamic trade effects as the explicit modal variable. The first three columns of the table use the explicit air share figure while the last three use the value to weight ratio. While the scale of the estimates differs because the share is constrained to lie within $[-1,1]$ and the ratio has no such constraint, the overall pattern demonstrated by the results is almost identical.

This is clearest in the final two rows which use the distances between US and Canada and US and China to show the overall coefficient on the air suitability figure. When using the explicit measure, Canada has a negative coefficient and China has a substantially large, positive

coefficient. This indicates that trade in surface shipped goods grew faster from Canada while trade in air shipped goods grew faster from China. The same story emerges from the final three columns except in terms of varieties suitable or not for air transport. The final three columns produce smaller estimates of the impact on each country, but since the air suitability measure is not bounded, the overall impact is of similar magnitude. The results also show that the use of air suitability, by avoiding the endogeneity of modal choice, could produce better estimates.

The industry share variable enters the regressions here and throughout the rest of the results with the expected negative coefficient. Varieties that trade more heavily in the initial period grew slower than those with light trade in the initial period. The inclusion of industry fixed effects in the third and sixth columns does not alter the results significantly. Table 1 demonstrates that the proposed air suitability proxy works in the same manner as actual modal selection data in estimating trade dynamics. This implies that the value to weight ratio can be used elsewhere to perform a similar analysis. This is a boon for trade empiricists since value and weight data are frequently available while explicit modal data is not.

Table 2 provides the first use of this proxy in a setting where modal data is not available. This table analyzes the relationship between bilateral trade growth and air suitability both for US trade and the world over the period 1990-2000. In both cases Comtrade provides the trade data which aggregates imports and exports for each route into a bilateral flow¹¹. The first three columns present the estimates over only US trade routes while the last three columns include all world trade. In all cases the coefficient of the un-interacted variable is negative, though not significantly so, while the coefficient on the interacted value to weight ratio is significantly positive.

As in Table 1, I construct a measure of how the growth impact of air suitability varies with distance. Rather than compare the Canadian to the Chinese experience, I calculate the distance at which the coefficient on the value to weight ratio is 0. This distance, which I label the cutoff point, identifies the routes on which varieties not suitable for air transport grew faster and those on which the opposite held. For both the US only sample and the world these cutoffs are smaller

¹¹The process of constructing this trade variable is described in detail in Choate (2009). The alternative would set the unit of observation as the exports or imports and have two flows for each route, doubling the observations. Given the inherently symmetric nature of transport, this line of inquiry was not pursued but could be investigated in future work.

than they were in Table 1. This is likely caused by two factors. The Comtrade data excludes trade with Belgium, Germany, and Taiwan, each of which is expected to ship high quality goods. The data also contains less information on variety weights which results in sample almost 40% smaller. Despite these differences, the estimated coefficients do not differ significantly from those in Table 1.

This is not true of the world estimates which have both significantly smaller estimates for the non-interacted and interacted value to weight ratio. The estimated cutoff is also smaller and indicates that on practically all routes varieties suitable for air transport grew faster¹². However the same pattern emerges for the entire world: trade in varieties suitable for air transport grew faster and this growth differential increased with the length of the trading route. This combination indicates that the cause is decreasing relative air to ocean transport costs and not an increased desire for quality goods or a difference in growth rates across countries or regions.

Tables 1 and 2 looked at the effect of declining relative transport prices on growth over the 10 year period 1990-2000. The remaining tables break the sample into 5-year time periods from 1965-2005. The estimated growth impacts in these tables are not directly comparable to the first two since the period lengths are different. Table 3 regresses trade growth over a 5-year period against the value to weight ratio and industry share in the initial period. The coefficients on the variables of interest are constrained to be constant across periods. Time variation is picked up by exporter-year fixed effects for the US only regressions or route-year fixed effects for the world regressions. In all cases the errors are clustered at the route level.

The estimated impact of declining relative transport prices over the long run is similar to that for the shorter run in Tables 1 and 2. The coefficient on the value to weight ratio is negative and significantly so for the world trade regressions. The coefficient on the interaction of this variable with distance is significantly positive across all specifications, and it is consistently higher for the US only sample. This implies that the cutoff point is lower for American trade than it is for world trade. For both samples, though, the cutoff remains low and only a few routes are sufficiently short so that trade in varieties unsuitable for air shipment grew faster.

¹²The shortest route in the data is from Congo (Kinshasa) to Congo (Brazzaville) which measures 4km.

Over the long run, the evolution of air transport has not been a smooth process. The 747, the work horse of international air freight and the first plane designed to fit cargo containers two-wide into its hold, was not commercially introduced until 1970. The early 70s also saw the oil shocks which led to absolute rises in both the price of air and surface transport. The latter price rose faster so air transport prices still declined in relative terms, though not monotonically. Figure 1 charts the evolution of both oil and relative air transport prices. Large markers indicate the growth rate over the subsequent 5-year period, so the points for 1965 indicate that oil prices¹³ fell by 7% from 1965 to 1970 while the relative air to ocean transport price¹⁴ fell by 32% over the same period. The lighter, smaller markers show yearly changes in the relative air to sea price index, with the figure for a given year equivalent to the growth rate over the subsequent year. Each series ends in 2003, so rises in oil prices after the start of the Iraq War are excluded.

Table 4 examines whether any relationship can be inferred between the observed changes in relative transport price and the estimated impact of those changes. To do so, the sample is split into the same 5-year periods, but each is analyzed separately. Errors are still clustered at the route level, and route and industry fixed effects are included. The results presented are the coefficients on the value to weight variables and are comparable to the final column of Table 3. They show that the general pattern found in Tables 1-3 holds when broken into 5-year periods. The exceptions to this rule are the two earliest periods when air transport was significantly smaller in capacity and more expensive in absolute terms. From 1975 onwards the coefficient on value to weight is negative in every period and significant in most. The coefficient on the interacted variable is positive and significant during all periods.

The evolution of the cutoff can be used to examine the changing relation of trade growth to air suitability. From 1975-2000 the cutoff is small enough that on all but the shortest of routes, air suitable varieties grew faster than the industry mean. During this period, trade in varieties unsuitable for air transport grew on only 0.25% of routes at maximum. After 2000, though, the

¹³Oil figures from the EIA are annual prices per gallon on gasoline in real terms. The raw data is available at: http://www.eia.doe.gov/emeu/steo/pub/fsheets/real_prices.html.

¹⁴Figures from Hummels 2007. His data consists of two indices for air to tramp and air to liner prices. I've combined them into one index by assuming half of trade came via each method. This simplifying assumption smoothes the rather noisy indices he reports. Some of this noisiness can be seen in the annual figures plotted.

relative transport price changes lessened and both air and sea transport costs rose in absolute value. During this period the cutoff soared to nearly 2,900km implying that on 16.5% of routes goods unsuitable for air transport grew faster. The air growth impact also declined relative to earlier periods. This can be seen by comparing the estimated value to weight ratio coefficient for a route with length 5,600km, which is approximately the distance from England to the US. The estimated coefficient on value to weight exceeded 4 on this route for every period until 2000 when it fell to 0.6. This is consistent with the expected impact of a slower relative price decline.

Another explanation could be the rise of regional trading blocs such as NAFTA and the EU. Table 5 splits the sample by intra- versus inter-regional trade routes¹⁵. One problem with this definition is that some of the regions are defined quite broadly so that intra-regional trade can be on routes longer than 9,000km. A second way to divide the sample is to break into groups based on the length of the route. The final two columns of Table 5 follow this approach and use 2,000km as the cutoff¹⁶. The downside of this approach is that trade that we would think of as inter-regional, such as Italy-Tunisia, is classified as intra-regional while some EU trade falls into the inter-regional group.

Despite these concerns, the results are similar across both approaches. The intra-regional trade displays both a higher cutoff point and a lower estimated growth impact for air suitable goods. This latter point is easily seen by comparing the maximum value to weight coefficient from the third column, 2.89, to the minimum coefficient for the fourth column, 2.94. On all inter-regional routes, trade in air suitable varieties grew faster, while on intra-regional trade this is not the case. For the shortest routes, trade in varieties not suitable for air transport grew faster, while for longer intra-regional routes, trade in air suitable varieties grew faster but not nearly so much as similar trade on inter-regional routes. These estimated impacts evolve in a similar manner over time to the results in Table 4. For both intra- and inter-regional routes, the cutoff remains low until the 2000-2005 period when it soars to above 2,000km. Since the evolution is consistent across the two

¹⁵The region definitions, while not reprinted here, are available from the author upon request and accord closely to the World Bank definitions. The regions are: NAFTA, South America, Sub-Saharan Africa, Middle-East North Africa, Europe, Central Asia, South Asia, Southeast Asia, and Pacific.

¹⁶This distance was selected somewhat arbitrarily and will place some EU trade in the inter-regional category. The analysis was repeated using 1,500km and 4,000km and the estimates were similar.

groups it is more likely to be driven by the declining relative transport prices than by a rise in regional trade agreements which would alter trade flows differentially between the two groups.

Given that the results so far demonstrate a significant relationship between variety level trade growth and air suitability, a natural question to examine is whether this benefit will accrue to some countries and not others owing to geography. This line of thought is followed by Feyrer (2008) who tries to use the long run relative price decline as an exogenous shock to trade in a manner akin to Frankel and Romer (1999). The drawbacks to this approach are discussed more fully in Choate (2009), but the main problems are shown in Tables 6 and 7 and arise from two factors. First, the benefits of the relative price decline accrue only to producers of goods that may be shipped by air. The first two columns of Table 6 list the proportion of varieties traded by each country that are predicted to grow faster because of the relative price movement. The first column uses results from the final column in Table 3 to make the predictions, while the second column uses the time-varying results from Table 4. The 19 countries included in Table 6 had the largest trade growth in the sample from 1965-2005¹⁷ and are sorted by proportion of varieties traded that are expected to benefit from the price shift. The predicted impact of the relative air transport price decline is constructed via:

$$\text{Impact}_{ijkt} = \hat{\beta}_{1t} \ln(\hat{v}pw)_{ijkt} + \hat{\beta}_{2t} \ln(\hat{v}pw)_{ijkt} * \ln(\text{distance})_{ij}$$

Where $\hat{\beta}$ is the fitted value from the regressions. The number of varieties with a non-negative predicted impact is summed across time periods and divided by the total number of traded varieties to produce the figures in the first two columns. Two patterns emerge from this aggregation. First, for almost half (three-quarters) of the countries in this list the proportion of traded varieties positively impacted by the shift in relative transport prices as predicted by the pooled (time-varying) estimate lies between [45%,55%]. For the entire sample the similar figures are 41% and 62.5%. This shows that for a large portion of countries, the relative transport price shock will have minimal impact since varieties that grew faster are nearly balanced with varieties that grew slower. The

¹⁷Germany and Belgium are excluded from this list because data is not available in Comtrade for either country prior to 1990.

countries for which the proportion positively impacted is larger than 55% tend to be either islands or landlocked countries that produce high quality goods. Switzerland, Ireland and Japan are the three examples in Table 6. The countries with an equally large proportion of trade negatively impacted are low quality good producers, China, or producers of commodities, Indonesia and Russia¹⁸.

The first two columns of Table 6 demonstrate how the characteristics of varieties trade will determine whether or not the air transport shock is positive or negative. The final four columns examine whether this is related to route length. *A priori* we may expect that countries that trade more air suitable varieties would trade on longer routes than those that trade less air suitable varieties. We also would expect that the average length of routes traded on would become longer as air transport prices decline. The middle two columns show that the first expectation is untrue. Indonesia and Japan have the longest average route lengths and two of the three longest trade weighted average route lengths, yet the two countries receive almost opposite benefit from the transport price shift. The change in average route length from 1965 to 2005 is equally muddled. The average length rises for almost all countries, perhaps owing to cheaper air transport, but the trade weighted average length falls for almost all of those same countries. There is no apparent relationship between the proportion of varieties traded that are positively impacted by the price shift and the evolution in the trade weighted distance of partners.

The only consistent relationship in Table 6 is between the impact of the price shock and the relative level of development. Highly developed countries tend to benefit, while trade from less developed countries grows slower than expected. Table 7 attempts to quantify the overall impact for each country by converting the predicted impact into both growth and difference terms. An estimate of the difference in trade between period t and t+1 caused by the shift in relative prices is given by:

$$\text{Air_Effect}_{it} = \sum_{jk} \text{Impact}_{ijkt} * \frac{\text{value}_{ijk,t} + \text{value}_{ijk,t+1}}{200}$$

The figure inside the summation is the proportion of the difference between variety trade values

¹⁸Oil producing countries do not appear on this list because crude oil trade was dropped from the sample.

attributed to the air transport price shock. The overall estimated difference in country trade over the same period can be produced by substituting the fitted values from equation 1 in place of the Impact variable. These figures are normalized by the actual growth in trade in Table 7.

A second measure of the impact of the relative price shift converts the predicted bound growth effect, Impact, into a predicted growth effect, γ via:

$$\gamma_{ijkt} = \frac{200 + \text{Impact}_{ijkt}}{200 - \text{Impact}_{ijkt}}$$

The weighted average of this predicted growth rate, using the proportion of trade by value in the initial period as the weights, provides another indication of whether the overall air impact is positive or negative. If a country has positive impacts in lightly traded varieties but negative impacts in heavily traded varieties, then the overall negative effect would be captured by this measure but not necessarily by the proportion of traded varieties for which the air impact is positive.

Table 7 shows the estimates for these variables for both the pooled and time-varying estimates. Two things are clear from the figures in this table. First there is a significant downwards bias across the estimates. While the fitted growth predictions match the means of actual growth which tend to be positive at the country level, the same is not true when inflated to difference figures. The closest the predicted changes in trade levels come to the actual changes is 78% of the true value for Poland. The downward bias is caused by mis-prediction of growth rates for the heaviest traded varieties¹⁹. The downward bias is also evident in the predicted air effect. While the predicted growth effect evenly divides the sample into positively and negatively affected varieties, once inflated to differences, the negative observations swamp the positive. The aggregate air effect is positive for only 9% (17%) of countries when calculated using the pooled (time-varying) estimates.

Even with this downward bias, one clear trend emerges from the second column of Table 7. Over the long run, the transport price shock alters trade growth by less than 7% in either direction. The countries that benefit are those that produce a higher proportion of air suitable goods. The countries hurt the most are those that tend to produce commodities, like Brazil, or goods less

¹⁹The bias shown in the table is actually reduced relative to what it would be if trade in petroleum products was not removed.

suitable for air shipment, like China. This shows that the main predictor of whether a country will benefit from the relative transport price movement is the air suitability of the varieties it trades. This implies that it is unlikely that the impact of the price change can be captured purely through geography. These results also hold for the weighted implied growth rate. The air effect tends to shift growth rates by a small amount that tends to be negative. Irish trade growth over the period is between 0.9-3.4% higher because of the relative price shift, while the Japanese experience is negative.

Despite aggregate impacts from the transport price shift being less than 3% in either direction for almost half of the countries, the relative price movement could still have larger true impacts. Since most countries have an almost even number of positively and negatively affected varieties, in aggregate these impacts cancel out, but this obscures larger within country impacts. At the firm level, the effect of cheaper air transport is expected to be quite substantial, as individual firms may enter or exit trade markets completely. This might also result in a net shift of workers from less to more productive firms. This question should be investigated in future work.

4 Conclusion

This paper expands on the prior literature by producing the first direct measurement of the impact of declining relative air to ocean transport prices on world trade flows over the period 1965-2005. The results verify the predictions of existing models and show that varieties more suitable for air shipment than the industry mean experienced significantly faster trade growth. This relationship increases quickly with distance, so that the largest trade gains are on the longest routes. Along shorter routes, the price shock has smaller impact or predicts that trade in goods unsuitable for air transport will grow faster.

Since explicit measures of the transport mode used are not available for world trade data or for the longer time spans examined here, I propose an alternative measure that captures the suitability for air transport. The logged ratio of value to weight for a given variety was shown in the past to correlate with the decision to use air transport. Here I have shown that it can also be used to

capture the trade dynamics caused by the relative transport price shock. As this figure is available for almost all trade datasets, this presents numerous opportunities for future research into the effect of transport price movements on trade flows including at the firm level.

These impacts are significant for variety level trade flows, but their magnitude is small at the country level. This occurs because most countries produce a range of goods and trade with partners of varying distances. This means that for nearly two-thirds of the countries in the sample, the proportion of the varieties they trade that are positively impacted by the relative price shift lies between 45-55%. Aggregating over these cancels out much of the predicted impact of the relative transport price shift. For almost half of the countries in the dataset, the shock altered trade growth over the long run by less than 3% in either direction. Future work should examine the firm level responses where the impact is expected to be larger in magnitude.

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Table 1: US Import Growth versus Air Transport Usage

	Δ_m Trade (1990-2000)					
$\hat{\text{Share}}$	-104.031*** (30.220)	-104.630*** (30.139)	-84.827*** (29.879)			
$\hat{\text{Share}} \times \ln(\text{distance})$	16.392** (3.427)	16.378*** (3.418)	14.219*** (3.388)			
$\ln(\hat{\text{vpw}})$				-13.336*** (3.760)	-13.464*** (3.749)	-17.574*** (3.719)
$\ln(\hat{\text{vpw}}) \times \ln(\text{distance})$				1.989*** (0.445)	2.007*** (0.444)	2.541*** (0.440)
Industry Share		-4.735*** (0.376)	-4.208*** (0.377)		-5.081*** (0.390)	-4.500*** (0.391)
Observations	29,525	29,525	29,525	28,555	28,555	28,555
R-squared	0.07	0.08	0.11	0.06	0.07	0.10
Industry Controls	no	no	yes	no	no	yes
Canada	-2.79	-3.48	2.99	-1.05	-1.07	-1.88
China	47.67	46.94	46.76	5.08	5.11	5.94

Standard Errors in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.

Constant term suppressed. All regressions include exporter fixed effects.

Customs data from the US Imports of Merchandise dataset.

vpw indicates the variety ratio of value to weight, and $\hat{}$ indicates that the industry mean has been subtracted from the variable.

Table 2: Bilateral Trade Growth versus Value per Weight

	Δ_m Trade (1990-2000)					
$\ln(\hat{v}pw)$	-11.840 (9.342)	-12.709 (9.336)	-10.182 (9.277)	-1.990 (1.475)	-1.899 (1.474)	-1.863 (1.468)
$\ln(\hat{v}pw) \times \ln(\text{distance})$	2.641** (1.073)	2.722** (1.072)	2.452** (1.065)	0.987*** (0.177)	0.968*** (0.177)	1.014*** (0.176)
Industry Share		-3.345*** (0.630)	-4.217*** (0.655)		-24.554*** (1.357)	-25.747*** (1.361)
Constant	32.646*** (0.824)	33.381*** (0.835)	41.316*** (4.425)	23.366*** (0.215)	23.733*** (0.215)	25.914*** (1.686)
Observations	17,762	17,762	17,762	299,587	299,587	299,587
R-squared	0.09	0.09	0.11	0.12	0.12	0.13
Sample	US	US	US	World	World	World
Industry Controls	no	no	yes	no	no	yes
Cutoff (km)	89	106	64	8	7	6

Standard Errors in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.
 US regressions include exporter fixed effects; world regressions include route fixed effects.
 Bilateral trade data from the UN's Comtrade dataset.

Table 3: Long Run Trade Growth versus Value per Weight (1965-2005)

	Δ_m Trade					
$\ln(\hat{v}pw)$	-7.811 (5.144)	-8.455 (5.231)	-6.120 (5.199)	-5.172*** (0.649)	-5.103*** (0.647)	-4.899*** (0.641)
$\ln(\hat{v}pw) \times \ln(\text{distance})$	1.667*** (0.581)	1.729*** (0.592)	1.477** (0.588)	0.984*** (0.078)	0.972*** (0.078)	0.969*** (0.077)
Industry Share		-2.159*** (0.421)	-2.478*** (0.469)		-14.577*** (2.036)	-14.856*** (2.041)
Constant	19.770*** (0.055)	20.258*** (0.118)	18.337*** (1.569)	25.959 (13,641)	26.177 (14,006)	21.422 (14,027)
Observations	148,796	148,796	148,796	2,678,401	2,678,401	2,678,401
R-squared	0.09	0.09	0.10	0.05	0.05	0.06
Sample	US	US	US	World	World	World
Industry Controls	no	no	yes	no	no	yes
Cutoff (km)	108	133	63	192	191	157

Standard Errors in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.
 US regressions include exporterXyear fixed effects; world regressions include routeXyear fixed effects. All regressions are on bilateral trade data from Comtrade at 5 year intervals.

Table 4: Time Varying Growth versus Value per Weight (1965-2005)

Period	ln($\hat{v}pw$)		ln($\hat{v}pw$) X ln(distance)		Observations	R^2	Cutoff (km)
1965-1970	2.314	(2.553)	0.480	(0.310)	157,712	0.10	124
1970-1975	1.121	(1.884)	0.246	(0.230)	196,636	0.12	95
1975-1980	-6.783***	(2.199)	1.305***	(0.264)	238,731	0.11	181
1980-1985	-3.651*	(1.879)	1.154***	(0.227)	272,627	0.09	24
1985-1990	-6.728***	(1.914)	1.256***	(0.230)	271,331	0.12	212
1990-1995	-1.520	(1.830)	0.664***	(0.219)	319,790	0.10	10
1995-2000	-5.526***	(1.282)	1.180***	(0.156)	498,438	0.09	108
2000-2005	-7.064***	(1.063)	0.888***	(0.129)	703,173	0.10	2,850

Standard Errors in parentheses: * significant at 10%; ** significant at 5%; *** significant at 1%.
 All regressions include route and industry fixed effects, and market share controls.
 All regressions are on bilateral trade data from Comtrade at 5 year intervals.

Table 5: Growth versus Value per Weight by Region (1965-2005)

	Δ_m Trade			
ln($\hat{v}pw$)	-9.371*** (1.507)	-2.234* (1.336)	-9.067*** (1.810)	-1.402 (1.512)
ln($\hat{v}pw$) X ln(distance)	1.606*** (0.213)	0.662*** (0.152)	1.573*** (0.264)	0.571*** (0.172)
Industry Share	-13.262*** (2.969)	-16.127*** (2.776)	-12.949*** (2.765)	-16.327*** (2.907)
Observations	820,392	1,838,046	775,433	1,883,005
R-squared	0.11	0.12	0.12	0.12
Sample	Intra-region	Inter-region	< 2,000km	>2,000km
Cutoff (km)	342	29	319	12

Standard Errors in parentheses: * significant at 10%; ** significant at 5%;
 *** significant at 1%. Regressions include routeXyear and industry fixed effects.
 All regressions are on bilateral trade data from Comtrade at 5 year intervals.

Table 6: Country Impacts of Declining Relative Transport Prices (1965-2005)

	% Goods Positively Impacted (pooled)	% Goods Positively Impacted (split)	Average Route Length (km)	Trade- Weighted Average Route Length (km)	Δ (Average Length)	Δ (Trade Weighted Length)
Switzerland	71.1%	68.6%	4,533	2,463	370	-366
Ireland	57.1%	54.3%	3,704	1,887	1,508	792
Japan	55.4%	55.3%	9,515	7,903	-30	-1,811
Austria	55.1%	54.7%	3,785	1,861	386	-767
Sweden	52.8%	52.6%	4,515	2,496	155	-577
France	52.4%	52.7%	4,904	2,668	163	-1,071
Great Britain	50.4%	49.6%	5,372	3,454	-306	-1,837
USA	48.1%	48.5%	6,949	6,219	451	-272
South Korea	45.6%	46.0%	7,999	5,968	2,473	390
Italy	45.4%	46.7%	4,624	3,054	104	-1,073
Spain	45.2%	46.5%	4,772	3,437	985	-627
Canada	45.2%	45.3%	6,601	4,114	1,117	-912
Netherlands	45.1%	46.3%	4,910	3,165	-44	-1,329
Brazil	44.7%	45.6%	8,203	9,275	771	1,297
Mexico	44.0%	47.1%	6,832	4,793	1,634	-1,144
Russia	36.7%	45.5%	3,382	4,282	695	-320
Poland	35.1%	41.6%	2,582	2,559	394	-1,174
Indonesia	33.6%	35.2%	8,654	8,010	-535	-2,456
China	28.9%	30.7%	7,948	5,364	1,751	247

Table 7: Country Growth Impacts of Declining Relative Transport Prices (1965-2005)

	Air Effect / Δ Trade		Δ Trade / Δ Trade		Weighted Air Growth Rate	
Switzerland	4.91%	3.90%	55.1%	50.6%	-0.43%	0.02%
Ireland	5.76%	2.57%	44.2%	35.9%	3.42%	0.89%
Japan	-1.91%	-3.09%	17.3%	12.0%	-0.48%	-0.86%
Austria	-0.08%	0.02%	75.6%	74.3%	-2.98%	-2.94%
Sweden	0.81%	0.26%	72.4%	71.5%	0.30%	0.04%
France	-0.28%	-0.62%	59.3%	54.4%	-0.08%	-0.25%
Great Britain	0.77%	-0.05%	56.5%	52.2%	0.27%	-0.05%
USA	-2.54%	-3.47%	22.5%	15.3%	-0.78%	-1.13%
South Korea	-2.62%	-2.58%	51.6%	48.0%	-1.01%	-1.10%
Italy	-0.79%	-1.05%	65.8%	64.0%	-0.21%	-0.36%
Spain	-1.63%	-1.54%	71.9%	69.8%	-0.76%	-0.78%
Canada	-4.66%	-4.85%	-0.2%	12.9%	-1.34%	-1.47%
Netherlands	-1.25%	-1.20%	59.9%	55.7%	-0.46%	-0.50%
Brazil	-7.06%	-6.67%	36.2%	32.7%	-2.50%	-2.59%
Mexico	-5.16%	-1.73%	57.0%	51.9%	-2.21%	-0.73%
Russia	-4.67%	-3.39%	63.4%	62.7%	-1.89%	-1.60%
Poland	-1.86%	-1.03%	77.8%	78.0%	-1.12%	-0.83%
Indonesia	-4.46%	-4.01%	54.8%	45.9%	-2.10%	-2.05%
China	-2.58%	-1.70%	71.5%	68.9%	-1.73%	-1.36%
Sample	Pooled	Time-varying	Pooled	Time-varying	Pooled	Time-varying

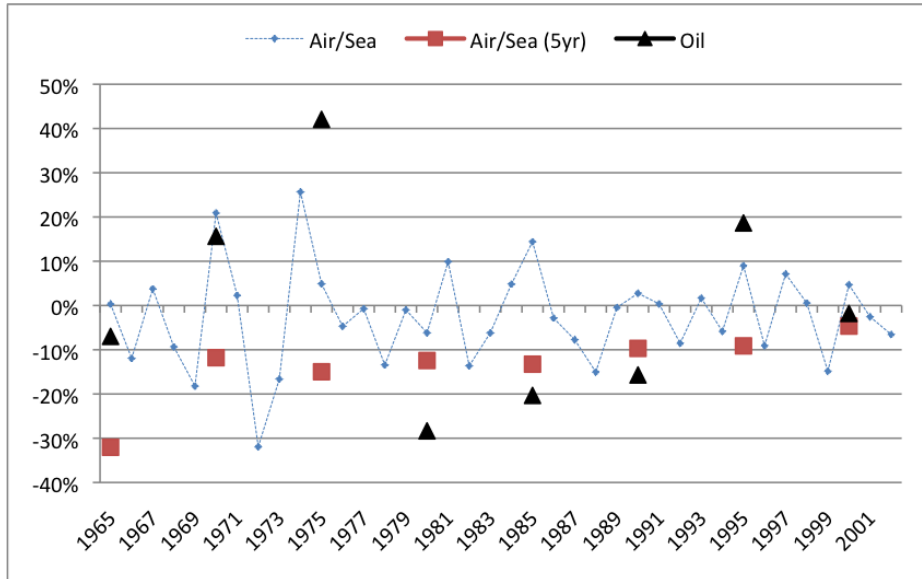


Figure 1: Price Change on Previous Period