

# Relative Transport Price Movements and US Imports

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November 7, 2008

## Abstract

From 1990 to 2000 air transport prices on US imports fell by 14% in absolute terms and by 31-39% relative to ocean transport prices. This paper estimates the impact of the relative price movement on the composition and volume of trade flows. I show that within an industry, imports shipped 10 percent more frequently by air than the industry average grew 2.1-5.3% faster over the decade than the representative industry import. This is equivalent to a tariff reduction of 1-3.7 percent on such goods. Controlling for the endogeneity of transport mode by using geography and goods characteristics reduces these estimates slightly and reveals that the aggregate impact of the price movement divides the world into three groups. Within an industry, trade in goods shipped less frequently by air grows fastest from NAFTA countries. Trade in goods shipped more frequently by air grows fastest from other OECD countries, and this shift in relative transport prices acts as a tax on developing country exports as they tend to be lower value to weight goods. In addition to altering comparative advantage among countries, the relative transport price movement has similar effect within countries. Worldwide the relative price shift redistributes \$5b worth of production, or 1.7% of total imports in 2000.

## 1 Introduction

The relationship between trade costs and trade flows has long been studied. The idea that transport costs increase with distance underlies the gravity model, the workhorse of trade empirics, while the notion that differential tariffs can have large distributional and welfare impacts is omnipresent in trade negotiations. Yet the effects of changing relative air to ocean transport prices

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\*email: dac2114@columbia.edu. I would like to thank David E. Weinstein and Kiki Pop-Eleches for both their guidance and encouragement. I would also like to thank Joseph Stiglitz, Donald Davis, James Harrigan, Eric Verhoogen, Dan Neilson, Matt Wai-Poi, Justin Svec, Guru Sethupathy, Gideon du Rand, and seminar participants at Columbia University for helpful comments and suggestions. Financial support from Columbia University and the NSF is acknowledged and greatly appreciated. All errors are my own.

remain understudied despite significant changes in the relative prices and substantial differences in the strengths of the two transport modes.

Air transport is the more expensive mode, but using it substantially reduces time to market and hence spoilage, the inventory cost of goods in transit, the uncertainty of delivery time, and uncertainty related to market demand. Furthermore, these effects are increasing with distance meaning that air transport use puts distant producers on equal footing with producers in nearby countries. Because of these advantages, a reduction in air transport prices relative to ocean transport prices is expected to increase the proportion of US imports shipped by air. In aggregate these expectations hold for the 1990s. At the start of the decade, 27.8% of the value of non-NAFTA imports<sup>1</sup> was shipped by air. This figure rose to 39.1% in 2000. This paper is the first to estimate the how this impact works on a more disaggregated level and what effect the relative price movement will have on the sourcing and composition of US imports.

Intuitively, declining relative air to ocean transport prices should lead to increased trade in perishable goods, transport mode switching by producers, and shifting intra-industry comparative advantage. However, the first two stories have minimal explanatory power. Trade in perishables accounts for at most 5% of US imports, and likely much less since this figure includes coffee and tea. Similarly, the percent of value sent by air for the average variety<sup>2</sup> increased by only 0.2% over the decade, and no relationship was found between the change in variety air share and trade growth.

The story with the most traction in the data is one of intra-industry shifts in comparative advantage. Industry here refers to 4-digit goods<sup>3</sup> with "mens' or boys' overcoats, carcoats, capes, cloaks, anoraks, windbreakers and similar articles, knitted or crocheted, other than those of heading 6103" being a typical example. Within this industry, those varieties shipped more intensively by air than the average variety are expected to benefit from the changing relative transport prices. If mens' coats made of wool tend to be shipped by vessel while such coats made of silk tend to be

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<sup>1</sup>The respective figure including NAFTA trade was 20%. The gap between the two rose to 10 percent in 1993 and has remained in double digits ever since.

<sup>2</sup>A variety refers to a combination of good and country. Countries can export many goods, and each of them is a unique variety. If two countries export the same good, then they are different varieties owing to the point of origin.

<sup>3</sup>All numbering of goods follows the US Harmonized Tariff schedule.

shipped by air, then the price drop should lead to increased trade in silk coats. Likewise, if Italy makes higher quality wool coats than China and ships them by air while China ships by sea, then Italian wool coats are expected to grow faster.

For all varieties traded in both 1990 and 2000 those shipped by air 10 percent more frequently than the industry average grew 5.3% faster over the decade than did those varieties shipped by air the average amount. As an example, if coats are shipped by air 50% of the time<sup>4</sup> and Italian wool coats are always shipped by air, then Italian wool coats are estimated to grow 26.5% faster than the average coat over the decade. Conversely, if Chinese coats are always shipped by vessel, then they are estimated to grow 26.5% slower than the average good. This growth differential can be converted to effective tariff terms. In order to offset the impact of declining relative transport prices, tariffs would have to be raised 3.5 percent<sup>5</sup> for each 10 percent increase in air shipment relative to the mean. Returning the same example, a tariff increase of 17.5 percent on Italian wool coats would offset the growth bonus from the relative transport price movement.

These figures are calculated using intensive margin trade data and actual air share figures. Both of these choices could bias the results. Restricting the sample to intensive margin data excludes 58% of trade growth over the decade, and the decision to use air transport may suffer from selection biases and other forms of endogeneity. To address these concerns geography and goods characteristics are combined into a measure of air suitability. Goods shipped longer distances are more likely to be air shipped, as are goods that come from a landlocked country. Higher value to weight goods are also more likely to use air shipment. The combination of these stylized facts produces a measure of suitability for air shipment. Intra-industry differences in this measurement are correlated with trade growth. Those varieties that are differentially more suitable for air transport than the industry average, either due to country or origin, or the value to weight of the variety<sup>6</sup>, will grow faster over the decade due to the declining relative air transport prices.

Restricting the analysis to only intensive margin trade but controlling for the endogeneity of

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<sup>4</sup>This figure refers to the percent of imports by value shipped by air for a variety and to the number of shipments that come by each mode.

<sup>5</sup>Here and elsewhere percent is taken to mean actual points of percent as opposed to a relative term when they will be denoted by %.

<sup>6</sup>This measure may be correlated with quality, and this relationship will be examined in more detail below.

transport mode, a variety 10 percent more suitable for air transport than the industry mean grows 2.6% faster over the decade. This is equivalent to a tariff reduction on this variety of 1.9 percent. Expanding the analysis to include as much of the extensive margin as possible does not alter this impact substantially. For the full dataset, a variety 10 percent more suitable for air transport grows 2.9% faster over the period which could be offset by raising tariffs on such varieties by 1.4 percent<sup>7</sup>. In each of these cases, the impact of declining relative air transport prices increases with distance. For countries within the Caribbean Basin, surface shipped goods actually grow faster. Canadian goods 10 percent less suitable for air transport grew 1.6% faster than goods at the industry mean. However, for varieties shipped from further than the Caribbean Basin, the air impact turns positive. Chinese goods 10 percent more suitable for air transport grew 4.1% faster.

The decline in relative air to ocean transport prices divides exporters into three groups. Goods less suitable for air shipment grow fastest from nearby countries, while those more suitable for air shipment grow fastest from more distant countries. However, since developing countries tend to produce low value to weight goods, while developed countries produce high value to weight goods, the effect of declining relative transport prices is positive for OECD countries and acts as a tax on exports from developing countries. I estimate that Canada and Mexico export 2% and 1.1% more to the US in 2000 than they would have without the relative price shift with the additional exports coming from goods within each industry less suitable for air transport. Likewise, European countries export up to 3% more to America in 2000 owing to a combination of higher value to weight good production and geography. Asian exports, excluding Japan, fall by 0.1% to 2.3%. For each group, the impact is larger when measured as a percentage of trade growth as opposed to final period trade.

Beyond influencing country level exports, the declining relative transport prices had large distributional impacts within countries as well. Japan is the best example of this. The overall positive impact of the price movement can be divided into two groups. Industries, including car parts, gain \$151.5m in exports relative to what they would have under the counterfactual, while other industries, such as film and paper products, lose \$112.5m in exports. The overall impact belies

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<sup>7</sup>The estimated offsetting tariff is lower in this case despite a higher implied growth rate because the estimated effect of changing tariffs is larger for the full sample.

the larger distributional story within the country where \$264m of trade oriented production was altered. Worldwide this figure is \$5.05b, or 1.7% of US imports in 2000. To explain how the relative transport price movement can lead to such a large effect, Section 2 reviews the literature on trade costs and modal choice and outlines the theorized impacts of declining air prices. Section 3 sketches the dataset and the methodology for analyzing it. Section 4 presents the initial results, and Section 5 concludes.

## 2 Literature Review

Hummels (2007) was the first paper to bring the large relative decline of air to ocean transport prices to light. He showed that from 1960 to 2000, air transport prices fell 87%. Excluding petroleum products, air transport prices fell 71%-88% relative to vessel transport prices, with the range arising from the way different types of vessels were handled. Over the period this paper is concerned with, his figures show that air transport prices fell 16%-22% relative to vessel prices. These figures, which are similar to the ones found in the data used for this paper, are large enough to expect that this movement will have a substantial impact on trade flows.

There are, though, only a few papers that analyze the relationship between transportation mode and trade. Harrigan (2006) is the first paper to explicitly model the decision. In his model firms choose between ocean and air transport. It is more expensive to transport goods by the latter method, but they receive a premium in the market. While not explicitly modeled, this air 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 quite large. He estimates the reduction in air transport costs from 1950 to 1998 is equivalent to a tariff reduction of 23 points on air shipped goods. This effect is estimated by estimating the relationship between prices and modal selection, and neither directly examines export dynamics nor controls for endogeneity of

transport mode as my paper does.

Harrigan's model makes two predictions about the effect of a reduction in relative air transport costs on US imports. First, producers that ship by air will gain market share, or grow faster, than producers of the same good that ship by surface methods. Second, goods that are less suitable for air transport will grow fastest from nearby countries. Effectively, the declining air prices allow more distant countries to capture market share in air shippable goods, which drives workers in the nearby countries to production of surface shipped goods where they maintain a comparative advantage. The results of this paper support both of these hypotheses.

Harrigan's model, though, says little about the expected magnitude of the transport price shock. This magnitude will depend on how large transport costs are relative to total trade costs. If Anderson and van Wincoop (2004) are correct to argue that transport costs make up only a small portion of trade costs, then the relative transport price movements may have little impact. If, however, the unobserved trade costs are equal across all partners, then differential transport costs may matter since transport costs account for more than 75% of observable trade costs. The magnitude could also be reduced if transport prices and modal choice are endogenously determined. Hummels et al (2007) and Jacks and Pendakur (2008) provide evidence that the price endogeneity exists. The Hummels paper tries to explicitly measure the endogeneity by looking at the relationship between vessel transport prices and then number of firms operating on a given route. It finds that where trade volumes are higher, competition among firms is higher, and transport prices are lower.

To address these concerns, three steps are taken in this paper. First, explicit transport price measurements are never used directly. Indirectly, the declining relative air to ocean transport price drives the results, but this effect is captured through use of initial period air usage or an air suitability measure. This permits me to avoid complications arising from how to control for changing composition when measuring changing transport prices. Second, as already mentioned, initial period figures are used. In order for there to be endogeneity concerns between initial period air usage and subsequent growth, the initial period air usage would have to be a response to predicted declines in relative air to ocean transport prices. Given the difficulty of predicting

oil prices over the next three months, this seems an unlikely story for the ten year period under examination. Finally, a measure of air suitability is constructed from a combination of goods characteristics and geography. This proxy avoids some of the selection concerns. Combined, all three steps ensure that endogeneity of prices or selection are not driving the results.

### 3 Data and Methodology

The data to examine the relationship between relative transport price movements and trade comes from the US Imports of Merchandise dataset. This oft-used dataset has customs data, including the mode of transport, for US imports at the 10-digit variety level over the period 1990-2000<sup>8</sup>. For each 10-digit variety, there is one observation per customs district of import and district of unloading. While there are certainly interesting relationships between number of customs districts of import and transport mode, that level of detail is unnecessary for this paper, so these observations have been aggregated into one 10-digit variety observation<sup>9</sup>. All aggregation is done on level variables.

Once aggregated, the data was cleaned to remove errant observations<sup>10</sup> and all figures were converted to real terms through use of the US GDP deflator, obtained from the World Bank's World Development Indicators database. This data was then used to construct variables for the air share, tariffs, and freight costs for a variety. The first of these is the ratio of the value of a variety shipped by air to the total value imported<sup>11</sup>. This figure lies between 0 and 1. The latter two are ratios of tariffs and freight costs to total value imported. These *ad valorem* variables are allowed to exceed unity since a good may be marked up for resale once imported<sup>12</sup>.

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<sup>8</sup>Data is available for the period through 2005, but as the transport price movements are muddled after the start of the millennium, only the data for the 1990s are used. Data for each year covers the entire year of imports, except for 1996 which only runs through the end of November. Because of this, this year is used only for summary stats.

<sup>9</sup>The number of observations aggregated range from 1 to 302. The higher numbers are possible due to the combinations of different custom districts of entry and unloading. The average number of districts for products from NAFTA countries is 6. For non-NAFTA surface shipped varieties it is 4.6, and for non-NAFTA air-shipped varieties it is 6.9. Examining the factors behind these decisions is left to future work.

<sup>10</sup>The details of this process are recounted in Appendix A as are some robustness checks to ensure that this cleaning does not affect the results.

<sup>11</sup>This figure is not always equal to the total value implied by summing up the values imported by air and by vessel. Appendix A shows that using the implied value does not alter the results

<sup>12</sup>Restricting both to be no larger than unity does not change the results substantially.

Table 1 describes the changes in these variables over the entire period. Except where noted, the figures exclude NAFTA observations since trade from these countries tends to come overland. The figures reported here are all calculated in a manner analogous to the air share. Letting  $j$  index country of export,  $k$  the good, and  $t$  the year, the air share is:

$$Air\_share_t = \frac{\sum_j \sum_k air\_value_{jkt}}{\sum_j \sum_k value_{jkt}}$$

The price per kg measure puts the freight cost paid by mode in the numerator and the weight imported by mode in the denominator. The price per ton-km measure multiplies the weight in the denominator by the distance shipped before summing. Finally, the real price per barrel of West Texas Intermediate taken from the Energy Information Administration is shown in the final column.

Table 1 shows that over the 1990s the air share of imports has risen by 41%. If NAFTA trade is included, the increase is only 23%, but the overall pattern is similar. The price movements invert the air share movements and fall in per kg and per km-ton figures by 14% and 20% respectively. The former reaches a minimum in 1998, while the latter hits its minimum the following year. Relative to vessel transport prices, though, both figures fall throughout the whole period and are 31% and 39% lower<sup>13</sup>. No attempt is made in these figures to control for changing composition of goods traded in terms of value per weight or distance shipped. Nor is any attempt made to control for entry of new goods and trading partners. As such, the figures in Table 1 should only be read as indicative of the drop in relative air to ocean prices rather than as an exact measure of the relative movement.

In order to estimate the impact this relative transport price decline had on trade growth, it is necessary to choose a measure for growth. The standard growth measure is undefined if the variety is not traded in the initial period, and it is prone to outliers. These outliers could be addressed by setting any value above a given cutoff to be equal to that cutoff value. This technique, called Winsorizing, usually sets the cutoff equal to the 99th percentile, but it too would not be defined

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<sup>13</sup>These relative drops exceed those cited from Hummels (2007). If the full, uncleaned dataset is used, the relative drops are 14%-21%, in line with his figures.

for varieties that begin trading during the 90s. Two approaches that minimize outliers and are defined for extensive margin observations will be used. They are mean, or bound, growth rates and the log difference. The former of these, which I will denote  $\Delta_m$ , is defined as the difference in trade over the period divided by the mean trade:

$$\Delta_m T_{jk} = 200 * \frac{T_{jk,2000} - T_{jk,1990}}{T_{jk,2000} + T_{jk,1990}}$$

Here  $T_{jkt}$  is the value of trade in good k from country j during period t. The mean trade growth is bound by the range [-200, 200], so it is less prone to outliers. The other growth measurement used in this paper is the log difference. In order to ensure this figure, denoted by  $\Delta_{ln}$ , is defined for all varieties, I have defined it as:

$$\Delta_{ln} T_{jk} = \ln \left( \frac{1 + T_{jk,2000}}{1 + T_{jk,1990}} \right)$$

Adding one to both values is slightly artificial but must be done in order to ensure this figure exists for all observations. Summary statistics for all four measures of trade growth on the intensive margin are shown in Table 2. Both the mean trade growth and log difference behave as expected, greatly reducing the presence of outliers. Since total intensive margin trade grew by 79% over the period, the former measure understates trade growth. This suggests that my results, if anything, underestimate the true impact of declining relative air to ocean transport prices, but the mean growth rate is used as the primary measure in this paper as opposed to the log difference because it is easier to interpret. A mean growth rate,  $\gamma_m$ , can be converted to a standard growth rate,  $\gamma$ , so long as it is not equal to 200 via:

$$\gamma = \frac{2\gamma_m}{200 - \gamma_m}$$

With the outcome variables constructed, analyzing the impact of declining relative transport prices is straightforward. Recall from the earlier that the expected impact is to reallocate production within a given industry, like mens' coats. Coats shipped by air more frequently than the average coat should differentially benefit from the relative air transport price decline. To capture

this story, I need a measure of differential intra-industry air transport usage:

$$\hat{share}_{jk,1990} = Air\_share_{jk,1990} - \frac{\sum_{k \in k_4} Air\_share_{jk,1990}}{n}$$

Where  $n$  is the number of varieties traded in the industry<sup>14</sup>. This figure will lie in the range  $[-1,1]$ . Since  $\hat{share}$  measures deviation from the industry mean it should have no effect for industries like petroleum products where all varieties are shipped by vessels or if all goods in a given industry are shipped by air. The impact of declining relative transport prices can then be estimated:

$$\Delta_m T_{jk} = \beta_1 \hat{share}_{jk,1990} + \beta_2 \hat{share}_{jk,1990} * \ln(distance_j) + \beta_3 X_{jk} + \gamma_j + \epsilon_{jk} \quad (1)$$

This equation relates variety mean trade growth to variety level intra-industry air usage deviations, denoted by  $\hat{share}$ . This figure is included both alone and interacted with the distance the variety is shipped. This interaction is included to ensure that the effect being captured is that of declining relative air transport prices and not some other story. An increased demand for quality goods, say, could lead to a positive coefficient on the share, but it is unlikely to increase with distance. Country level secular trends and unobserved heterogeneity are controlled for with country dummies, and the vector,  $X_{jk}$  controls for changes in freight charges and tariffs. These costs come from the US Imports of Merchandise dataset and are expressed in *ad valorem* terms.

To minimize the effect of outliers and to increase the amount of extensive margin observations for which the proxy can be constructed, the freight and tariff costs are aggregated from the 10- to 8-digit level<sup>15</sup>. Letting  $F_{jkt}$  be the freight charges paid on 10-digit variety  $jk$  at time  $t$ , and recalling that  $T_{jkt}$  is the value of that variety imported in the same period, the 8-digit freight cost is:

$$F_{jk8t} = \frac{\sum_{k \in k_8} F_{jkt}}{\sum_{k \in k_8} T_{jkt}}$$

The 8-digit tariff is constructed in the same manner. Both of these *ad valorem* figures are then

<sup>14</sup>A weighted average of the air share could be used instead of the mean described here. This will have similar effect to weighting the regressions by the value of trade in a variety, and these impacts will be described in detail in the results section.

<sup>15</sup>This switch has minimal impact on the estimates.

differenced and scaled to percentage terms:

$$\Delta F_{jk_8} = 100(F_{jk_8,2000} - F_{jk_8,1990})$$

Differences are used for two reasons. They minimize outliers, and they have a more natural interpretation. A fall in tariffs from 40% to 20% may be expected *a priori* to have a larger impact than a fall from 4% to 2%. If a rate were used, as opposed to the difference, then these two changes would be treated identically. The former story fits the context better given that most tariffs are quite small for the period being examined.

The approach taken by equation 1 is quite similar to using 4-digit industry dummies except that it allows country effects and changes in observable trade costs to have uniform impact across all industries. Since the only within effect that I am interested in is the intra-industry air transport usage, this approach fits. Equation 1 excludes any actual air share usage and only uses deviations from the industry mean. This means that an industry predominantly shipped by air is treated the same as an industry shipped predominantly by vessel. This fits the story being told better than a regression that expects the relative air transport price decline to have differential impact based on average industry air transport usage. As an example, there is no *a priori* reason to expect imports of coats will grow faster than imports of cars because they are shipped by air more frequently.

By using deviations of actual air shares from the industry mean, equation 1 is restricted to observations that report initial period air share and is open to questions of endogeneity. To address both these concerns, I construct a measurement of how suitable a variety is for air transport. Harrigan (2006) showed that air shipped goods tend to travel further distances and have higher value to weight ratios. Denoting the 8-digit version of this latter variable as  $vpw$  and letting  $W_{jkt}$  be the total weight of variety  $jk$  imported in time  $t$ , the value per unit weight is given by:

$$vpw_{jk_8,1990} = \frac{\sum_{k \in k_8} T_{jk,1990}}{\sum_{k \in k_8} W_{jk,1990}}$$

The two stylized facts are then used to estimate the air transport decision (standard errors in parentheses):

$$\begin{aligned}
Air\_share_{jk,1990} = & \alpha_k + 0.06ln(vpw_{jk8,1990}) + 0.87ln(dist_j) - 0.06ln(dist_j)^2 \\
& (0.002) \qquad \qquad \qquad (0.027) \qquad \qquad \qquad (0.002) \\
& - 0.34border_j \qquad \qquad + 0.14locked_j \qquad + \epsilon_{jk} \\
& (0.009) \qquad \qquad \qquad (0.004)
\end{aligned}$$

This equation uses geographical characteristics and variety characteristics to estimate the portion of the variety shipped by air. As expected value to weight is positively correlated with air shipment, as is the distance, though this relationship increases less quickly the further a good travels. Locked and border are dummy variables that take on the value of 1 when the country is landlocked or shares a border with America respectively. The former is positively correlated with air shipment, while the latter is negatively correlated. Finally, a 6-digit good dummy,  $\alpha_k$ , is included to measure any unobserved heterogeneity. Returning to our example, this equation would have a separate dummy for wool coats and silk coats. If silk coats tend to be shipped by air more than wool coats, all else being equal, then this would be picked up by the goods dummy. Quality differences with wool coats would be captured by the value to weight figure.

This equation is estimated on the sample of varieties that have positive trade values in the initial period as well as air share and value to weight measures. These latter figures come from the Imports of Merchandise dataset. The distance measure is the Great Circle distance from the main city of the exporting country to either Los Angeles, Houston, or New York City, whichever is shortest. It is calculated by the author, and available upon request. The border and landlocked dummies come from Frankel and Romer (1999). Since the right hand side variables are available for many varieties that are not traded in the initial period, this regression can be used to generate air suitability measures for both those goods traded in 1990 and some of those not traded until later.

These fitted values must be censored to lie within the range [0,1] which is one of the two shortcomings of this approach. The suitability for air transport should be estimated via Tobit regression to account for the censored nature of the dependent variable. For computational reasons, however,

a Tobit can only include 4-digit goods dummies which forces the intra-industry differences to be driven purely by value to weight and geography. So a Tobit regression discards substantial heterogeneity within an industry. Because of this limitation, the fitted air suitability from the Tobit is compared to a 2-digit industry average when used in the analysis. This strains the substitutability rationality behind the intra-industry comparison but strengthens the precision of the estimate.

The second shortcoming of the main approach for estimating air suitability is that the equation cannot generate suitability figures for all of the out of sample observations. When a country does not trade any good within an 8-digit industry in the initial period, that whole 8-digit industry will be dropped for the country. This excludes only the fastest growing varieties from the analysis; so the full sample results may understate the true impact of declining relative air to ocean transport prices. The impact of this will be checked by estimating the air suitability equation with figures from the terminal period. This will exclude some varieties that ceased exporting between 1990 and 2000. Comparing the results of these two approaches will indicate how significant the exclusions are.

With the air suitability figure calculated, the de-meaned suitability figures can be constructed in a manner analogous to the de-meaned air share. This figure can be substituted for the *share* figure in equation 1:

$$\Delta_m T_{jk} = \beta_1 \hat{suit}_{jk} + \beta_2 \hat{suit}_{jk} * \ln(distance_j) + \beta_3 X_{jk} + \gamma_j + \epsilon_{jk} \quad (2)$$

If run on the intensive margin sample, this equation simply controls for endogeneity. However, it can also be estimated on the full sample to see if the impact alters once entry and exit are allowed. Note that the air suitability is used as a proxy rather than as an instrument. This was done because there are no air share measurements for the extensive margin observations. Using a proxy is the only way to include these observations<sup>16</sup>.

Finally, there could be concerns about including goods that are never shipped by air in the analysis. The inclusion of such goods should not matter if they are correctly recorded as having

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<sup>16</sup>Using the air suitability figure as an instrument for the air share on the intensive margin sample does not alter the results.

no intra-industry deviations in air transport usage. However, the data indicates that 0.0001% of American imports of crude oil in 1990 came by air as did 0.4% of passenger cars. Both of these cases are either outliers or unconnected to the main story. This is controlled for by dropping all goods where the 10-digit good mean air share is less than 1%:

$$Avg\_share_k = \frac{\sum_j \sum_t air\_value_{jkt}}{\sum_j \sum_t value_{jkt}}$$

If this figure is less than 0.01, then all observations of good  $k$  are removed from the dataset. This restriction removes 49% (43%) of trade value in 1990 (2000) including all petroleum products, vehicles, boats, and some heavy commodities. Airplanes are also included in this group which I refer to as "surface goods."

## 4 Initial Results

The previous sections discussed how air transport costs fell relative to vessel costs during the 90s and what the expected impact of this price movement is. The estimated impact of differential initial period intra-industry air transport usage on subsequent trade growth for the intensive margin data is shown in Table 3. The first column estimates equation 1 without the interaction term and finds that varieties shipped by air 10 percent more than the industry mean grew 5% faster over the decade<sup>17</sup>. Converted into equivalent tariff terms, the tariffs on such varieties would need to have grown by 3.7 percent to offset the benefits of cheaper air transport.

The second column of this table includes the interaction between distance and the intra-industry air share deviations and finds the effects increase with distance. For Canada, the closest country in the sample, the estimated impact for a variety shipped by air 10 percent more than the mean is 2.9% faster growth. For China the same figure is 5.5%. These first two columns exclude surface shipped goods. Including these goods in the middle two columns does not significantly alter the non-interacted results but does shift the intercept down for the interacted results. The figures

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<sup>17</sup>For ease of interpretation, all growth figures mentioned in this section have been converted into standard growth rates. Thus, the numbers cited will be different, and higher, than those in the tables which are in mean growth rates.

from the fourth column indicate that a Canadian variety shipped by air 10 percent more than the mean grew only 0.2% faster than the mean good. The estimated relationship between air transport usage and growth is much steeper though.

The final two columns weigh each observation by the average trade in that variety over the two time periods. Varieties traded in larger amounts are less likely to have large growth values. The results of the weighted regression continues the trend from the middle regressions. Once weighted, varieties from Canada shipped by air 10 percent more than the mean grow slower. Instead, Canadian goods shipped by air 10 percent less than the mean grew 1.3% faster. Chinese goods shipped by air 10 percent more than the industry mean still grew 7.7% faster, but the impact of declining air transport prices switches over after a cutoff distance has been hit. Here and elsewhere in these results, this cutoff will group the NAFTA and Caribbean Basin countries as places from which surface shipped goods within an industry grow faster. The goods more suitable for air shipment continue to grow faster from more distant countries.

This division of air impact is similar to the predictions of Harrigan (2006). Goods shipped by air more than the industry mean from distant countries grow faster, while goods shipped by air less than the industry mean from nearby countries also grow faster. In effect, those goods within an industry that are less suitable for air shipment are produced in the nearby countries, while those that are suitable for air shipment are produced in more distant countries. This pattern is repeated in Table 4 which uses the air suitability proxy in the place of actual air share to control for endogeneity<sup>18</sup>. Controlling for endogeneity reduces the estimated impact of declining relative air transport prices and brings the results into line with the weighted results from Table 3. For the full intensive margin sample, varieties 10 percent more suitable for air transport than the industry mean grew 2.6% faster, equivalent to a tariff reduction of 1.9 percent on such varieties.

When the interaction between distance and air suitability is included, again I find that surface suitable exports from nearby countries grew faster while the reverse is true for more distant countries. The cutoff for the switchover still lies in the Caribbean Basin. To check that the results in Table 4 are not caused by the choice of proxy, Table 5 repeats the analysis with different versions

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<sup>18</sup>The rest of the results in the paper are not weighted, but similar figures emerge from the weighted regressions.

of the proxy. The first three columns drop the value to weight figure and use 10-digit, 8-digit, and 6-digit goods dummies in the transport mode regression respectively. Each column finds similar results to those in Table 4. The final column of this table uses the air suitability measure generated by a doubly censored Tobit regression<sup>19</sup> and finds similar results. Using the Tobit extends the cutoff distance so that goods more suitable for surface transport grow faster from countries on the north coast of South America, but otherwise the results are unchanged. Similarly, Table 6 shows that the results are not caused by the use of mean growth rates. The air impact is equally significant in terms of the log difference.

Moving beyond the intensive margin, Table 7 analyzes the impact of declining relative air to ocean transport prices on the full sample. The first four columns use an air suitability proxy constructed from initial period data, while the final two columns use a proxy constructed from final period data. The use of initial versus final period data has minimal effect, as does the movement to the full sample. Similar to the results for the intensive margin, varieties shipped by air 10 percent more than the industry mean grew 2.9% faster. This is equivalent to a tariff decrease of 1.4 percent on these varieties. When the interaction term is included, varieties from countries within the Caribbean Basin shipped by air 10 percent less than the industry mean grow faster. The opposite is true for more distant countries.

Since the results demonstrate a significant impact of relative air transport prices on intra-industry comparative advantage, it is natural to ask how those variety level impacts will aggregate to the country level. For each variety the air impact can be quantified as:

$$Air\_impact_{jk} = \frac{\bar{T}_{jk}}{100} \left( \hat{\beta}_1 share_{jk} + \hat{\beta}_2 share_{jk} \ln(dist_j) \right)$$

Where  $\hat{\beta}_1$  be the estimated coefficient on initial period air share,  $\hat{\beta}_2$  is the estimated coefficient on the interacted term, and  $\bar{T}_{jk}$  be the mean trade in a variety. This air impact is the fitted estimate of the difference between the variety trade in the end and start periods.

This variety level estimated air impact can be used to estimate both the net and gross impacts of declining relative transport prices on country level trade growth. The former of these captures

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<sup>19</sup>While not reprinted here, the results of this regression are available from the author upon request.

the overall impact of the relative price movement on country trade growth. In doing so, some of the positive impacts of the price movement cancel out some of the negative impacts, so the final estimate understates the true magnitude of the impact. By taking absolute values of the air impact, I construct a measure that groups both the winners and losers together to estimate the amount of trade affected by the price movement.

$$Air\_impact_j = \sum_k Air\_impact_{jk}$$

$$Air\_churn_j = \sum_k |Air\_impact_{jk}|$$

To aid with the interpretation of these figures, they are normalized by either the country's trade growth or its trade in the final period.

The country level impacts of declining relative air transport prices are shown for the top 20 exporters by value in the initial period in Table 8. These impacts are based on the results from the final column in Table 4 meaning they are restricted to the intensive margin and use the air suitability proxy to avoid endogeneity concerns<sup>20</sup>. The first two columns of the table show the air impact and churn. The third column records the country's growth in intensive margin trade, and the fourth column expresses the air impact as a percentage of this figure. The final two columns report total intensive margin trade in 2000 and the air impact as a percentage of this.

Since nearly all varieties from Canada and Mexico are less suitable for air transport owing to their proximity, the two countries record positive impacts from the decreasing relative transport prices. Other countries leverage now cheaper air transport to compete in some markets, leaving the markets in heavier and less air suitable goods freer from competition. This pushes Canada's trade growth 4.2% higher than it would have been without the relative price decline. Total Canadian exports are 1.9% higher in the final period as well. These gains come in industries including aircraft engines, metals, and motor vehicles, while Mexico gains primarily in manufacturing components like valves and batteries.

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<sup>20</sup>Using the results with actual air share will switch the impact on Canada and Mexico to negative while leaving all other countries unaffected. Using the results from the full sample regressions will have minimal effect.

The other OECD countries also benefit from the relative transport price movement because of their distance from America and their tendency to produce high value to weight goods. Great Britain and Switzerland are the largest beneficiaries with exports in 2000 1.4% and 3% above the level they would have reached without the transport price drop. Asian exporters are adversely impacted by the transport price movement because they tend to produce low value to weight goods. Exports from these countries grew 0.3% to 22% slower than they would have under the counterfactual.

For many of the largest exporters, the impact of declining relative air to ocean prices was completely in one direction. Almost all Canadian and Mexican varieties benefitted, while most of the Thai varieties did not. However, some countries, like Japan, suffered large distributional costs that are hidden by the small overall impact. In Japan the relative price movement had a positive impact of \$151.5m on some industries while adversely affecting other industries by \$112.5m. The former group includes car parts and photographic paper, as Japanese varieties of these are more suitable for air transport than the industry standard. The latter group includes other film and paper products that are less suitable for air transport than the industry mean. This means that there will be a large distributional cost from the price change for Japan. For some industries, like photographic paper, the shift may lie entirely within a firm as it focuses on higher quality product lines. For other industries, the effect may entail workers finding new jobs, and this will have a large human cost. These distributional costs are important, and they are hidden by looking only at the country level effects. Aggregating the churn figures, which do capture these costs, across the world produces a figure of \$5.05b. This is equal to 3.8% of trade growth on the intensive margin, or 1.7% of such trade in 2000, demonstrating that the change in relative prices can have a significant cost both within countries and between them.

## **5 Conclusion**

The relative price decline of air to surface transport costs changed the competitive landscape for American imports. Within an industry, such as mens' coats, those varieties that are shipped by

air 10 percent more than the industry mean grew 5.3% faster over the 1990s. This is equivalent to reducing the tariffs on such goods by 3.5 percent. If an air suitability measure is used to control for the endogeneity of transport mode selection, these figures fall somewhat. A variety that is 10 percent more suitable for air transport than the industry mean grew 2.6% faster. This is the same as reducing its tariffs by 1.9 percent.

These effects vary substantially with distance. For countries close to the US like Canada, Mexico, and the Caribbean Basin states, varieties that are less suitable for air shipment than the industry mean grew fastest, while for more distant countries the opposite is true. The relative price shift has the effect of shifting production in heavier and less valuable goods to the countries closer to America. Production of air shipped goods grows fastest in Europe and other distant countries. This is a result of both geography and characteristics of the goods themselves.

Aggregated to the country level, the impact of the decline in relative transport prices is significant. Canadian and Mexican exports grew 4.2% and 1.7% faster over the decade than they would have without the price shift. Exports from OECD countries also grew faster due to a combination of high value to weight products and longer distances. Trade from European partners grew 3.3% faster on average, and exports from these same partners averaged 1.2% higher in 2000. While these countries grew, Asian exporters and developing countries lost ground. This effect is driven by the low value to weight ratio of the goods typically produced in developing nations. Export growth was 0.3% to 22% slower from these countries than it would have been had transport prices not changed. Their exports to the US were on average 1% less than they would have been.

Beyond serving as a tax on trade from developing countries, the change in relative transport prices has distributional consequences within countries. A country like Japan sees a minor overall impact from the transport price movement, but this conceals large shifts for industries within its borders. Some industries profit from the change while others lose, and the total value of these gains and losses is equal to 9% of Japanese trade growth over the decade. Summed across the world, these distributional costs exceed \$5b, or 4% of trade growth.

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## A Data cleaning

The discussion in the paper glosses over some of the difficulties faced in working with the Imports of Merchandise (IM) dataset. These difficulties arise primarily from a lack of documentation with the best example being the distinction between the general and consumption value of imports. No definition is offered in the documentation available to me for how these two values relate to one another. For the years 1990 and 2000, these two values are equal 92% of the time with the general value exceeding the consumption value in 6% of the remaining observations. Because I am unsure what if anything these differences mean, I restrict the analysis to the 92% of observations where the figures are identical. However, including all figures does not alter the findings.

The dataset also has a problem with internal consistency. Recorded for each observation is the value that came by vessel and the value that came by air. For non-NAFTA countries, these two figures should sum to the total value imported. Unfortunately this is rarely the case. Trade from France is perhaps the worst example since modal information is available for only 54% of the total value imported from there. Of the more than 1,000 goods imported from France, the implied trade value from summing across the modes of trade is equal to the reported total trade value for only 8 goods. For 3 goods, the discrepancy between these figures exceeds \$1b. As one way to address this, I restrict the analysis to those observations where the discrepancy is less than 10% of the reported total value imported. Doing so does not alter the main findings.

In addition to checking on the effect of sample restrictions, I also used both the consumption value of imports and the implied value of imports in place of the general value<sup>21</sup>. I then checked the results for the entire dataset and with the separate restrictions discussed above. In all cases, the main findings of the paper came through. While too long to list here, all of these results are available from the author upon request.

Table 1: Transport Mode Prices and Usage by Year

Year	Air Share	Air Share (with NAFTA)	Air Freight per kg	Vessel Freight per kg	Air Freight per km-ton	Vessel Freight per km-ton	Oil Price per Barrel
1990	27.8%	19.8%	\$2.25	\$0.05	\$0.32	\$0.01	\$30.06
1991	30.2%	21.2%	\$2.09	\$0.04	\$0.31	\$0.01	\$25.50
1992	32.5%	22.4%	\$2.09	\$0.05	\$0.31	\$0.01	\$23.82
1993	34.1%	22.9%	\$1.97	\$0.05	\$0.29	\$0.01	\$20.85
1994	34.0%	22.5%	\$1.97	\$0.05	\$0.29	\$0.01	\$19.06
1995	34.9%	22.1%	\$2.13	\$0.06	\$0.31	\$0.01	\$20.01
1996	33.9%	21.5%	\$1.91	\$0.05	\$0.27	\$0.01	\$23.57
1997	36.1%	22.9%	\$1.89	\$0.05	\$0.27	\$0.01	\$21.60
1998	35.4%	22.5%	\$1.87	\$0.05	\$0.26	\$0.01	\$14.95
1999	38.5%	24.2%	\$1.93	\$0.05	\$0.26	\$0.01	\$19.76
2000	39.1%	24.4%	\$1.93	\$0.06	\$0.26	\$0.01	\$30.38

All \$ figures in 2000 USD; NAFTA trade excluded except where noted

<sup>21</sup>Where the dataset set suggested an air share exceeding 1 under these other value variables, those observations were dropped.

Table 2: Intensive Margin Growth Summary Statistics

Growth Rate Type	Mean	Standard Deviation	Minimum Value	Maximum Value
Standard	2,964.1	73,784.5	-100	15,400,000
Winsorized (99%)	1,070.1	3,262.1	-100	18,734
Mean	23.1	126.7	-200	200
Log Difference	0.4	2.2	-9.99	11.9

All values calculated for 1990-2000

Table 3: Intensive Margin Air Impact (1990-2000)

	$\Delta_m(\text{trade value}) (\%)$					
<b>Air Share (1990)</b>	<b>40.178***</b> (1.374)	<b>-11.523</b> (16.393)	<b>42.130***</b> (1.309)	<b>-34.306**</b> (15.287)	<b>29.797***</b> (1.796)	<b>-143.35***</b> (11.249)
<b>Air Share X ln(distance)</b>		<b>5.931***</b> (1.874)		<b>8.786***</b> (1.751)		<b>22.159***</b> (1.367)
$\Delta(\text{tariffs})$	-1.074*** (0.123)	-1.064*** (0.123)	-1.201*** (0.115)	-1.183*** (0.115)	-4.734*** (0.150)	-4.759*** (0.151)
$\Delta(\text{freight costs})$	-1.316*** (0.142)	-1.311*** (0.142)	-1.017*** (0.105)	-1.014*** (0.105)	-2.435*** (0.136)	-2.468*** (0.136)
Observations	66,445	66,445	81,063	81,063	81,603	81,603
R-squared	0.06	0.06	0.05	0.05	0.11	0.11
Surface Goods	No	No	Yes	Yes	Yes	Yes
Weighted	No	No	No	No	Yes	Yes

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

Table 4: Air Suitability Impact (1990-2000)

	$\Delta_m (\text{trade value}) (\%)$			
<b>Air Suitability (1990)</b>	<b>19.358***</b> (4.760)	<b>-128.013***</b> (47.589)	<b>22.718***</b> (4.357)	<b>-199.058***</b> (40.203)
<b>Air Suitability X ln(distance)</b>		<b>17.115***</b> (5.499)		<b>25.950***</b> (4.676)
$\Delta(\text{tariffs})$	-1.058*** (0.124)	-1.052*** (0.124)	-1.214*** (0.116)	-1.201*** (0.116)
$\Delta(\text{freight costs})$	-1.348*** (0.143)	-1.347*** (0.143)	-1.039*** (0.105)	-1.039*** (0.105)
Observations	66,434	66,434	80,851	80,851
R-squared	0.04	0.04	0.04	0.04
Surface Goods	No	No	Yes	Yes

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

Table 5: Air Suitability Impact Using Different Proxies (1990-2000)

	$\Delta_m$ (trade value) (%)			
Air Suitability (1990)	<b>-92.441***</b> (32.491)	<b>-135.920***</b> (36.266)	<b>-147.459***</b> (40.339)	<b>-108.434***</b> (18.760)
Air Suitability X ln(distance)	<b>14.384***</b> (3.753)	<b>19.058***</b> (4.195)	<b>19.351***</b> (4.695)	<b>12.864***</b> (2.185)
$\Delta$ (tariffs)	-1.194*** (0.116)	-1.197*** (0.116)	-1.179*** (0.116)	-1.151*** (0.116)
$\Delta$ (freight costs)	-1.003*** (0.105)	-1.003*** (0.105)	-1.031*** (0.105)	-1.041 (0.105)
Observations	81,063	81,063	81,063	80,910
R-squared	0.04	0.04	0.04	0.04
Surface Goods	Yes	Yes	Yes	Yes
Proxy	10-digit	8-digit	6-digit	Tobit

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

Table 6: Intensive Margin Air Impact on Other Growth Measures (1990-2000)

	$\Delta_m$ (quantity) (%)		$\ln(1 + trade_{2000}) - \ln(1 + trade_{1990})$		$\Delta_m$ (market share) (%)	
Air Suitability (1990)	<b>53.876***</b> (1.565)	<b>-60.002***</b> (17.967)	<b>0.821***</b> (0.023)	<b>-0.562**</b> (0.271)	<b>39.423***</b> (1.304)	<b>-32.881**</b> (15.230)
Air Suitability X ln(distance)		<b>13.112***</b> (2.061)		<b>0.159***</b> (0.031)		<b>8.311***</b> (1.744)
$\Delta$ (tariffs)	-0.807*** (0.129)	-0.779*** (0.129)	-0.023*** (0.002)	-0.023*** (0.002)	1.435*** (0.114)	1.452*** (0.115)
$\Delta$ (freight costs)	-0.701*** (0.119)	-0.698*** (0.119)	-0.020*** (0.002)	-0.020*** (0.002)	0.636*** (0.104)	0.638*** (0.104)
Observations	68,007	68,007	81,063	81,063	81,063	81,063
R-squared	0.05	0.05	0.06	0.06	0.06	0.06
Surface Goods	Yes	Yes	Yes	Yes	Yes	Yes

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

Table 7: Full Sample Air Suitability Impact (1990-2000)

	$\Delta_m$ (trade value) (%)					
Air Suitability (1990)	14.750*** (3.643)	-64.571 (41.912)	24.953*** (3.335)	-110.352*** (35.901)	10.452*** 2.313	-133.43*** 35.736
Air Suitability X ln(distance)		9.092* (4.786)		15.586*** (4.118)		15.551*** 4.108
$\Delta$ (tariffs)	-1.738*** (0.084)	-1.737*** (0.084)	-1.778*** (0.080)	-1.777*** (0.080)	-1.741*** (0.080)	-1.750*** (0.080)
$\Delta$ (freight costs)	-0.023 (0.103)	-0.024 (0.103)	-0.038 (0.079)	-0.039 (0.079)	-0.114 (0.081)	-0.022 (0.078)
Observations	189,764	189,764	235,866	235,866	235,856	236,334
R-squared	0.08	0.08	0.08	0.08	0.08	0.08
Surface Goods	No	No	Yes	Yes	Yes	Yes
Proxy Data Year	1990	1990	1990	1990	2000	2000

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

Table 8: Intensive Margin Country Level Air Impacts (1990-2000)

Trading Partner	Air Impact	Air Churn	Trade Growth	Air Impact (as % of Growth)	Trade (2000)	Air Impact (as % of Trade)
Canada	2,080	2,250	49,700	4.2%	108,000	1.9%
Japan	39	264	2,890	1.4%	13,600	0.3%
Germany	129	216	4,220	3.1%	14,400	0.9%
Mexico	297	321	17,900	1.7%	26,000	1.1%
Great Britain	184	218	5,120	3.6%	13,200	1.4%
France	110	148	5,880	1.9%	12,700	0.9%
Taiwan	-28	107	569	-5.0%	5,140	-0.5%
Italy	66	111	2,600	2.5%	6,940	0.9%
Brazil	15	59	363	4.2%	4,070	0.4%
South Korea	-5	76	871	-0.5%	4,290	-0.1%
Belgium	38	49	1,650	2.3%	4,990	0.8%
Israel	-49	84	5,320	-0.9%	8,110	-0.6%
Sweden	51	65	2,550	2.0%	5,140	1.0%
Switzerland	117	120	1,450	8.1%	3,910	3.0%
Australia	-23	39	-154	-15.0%	2,200	-1.1%
China	-26	122	10,200	-0.3%	12,300	-0.2%
Thailand	-77	90	2,670	-2.9%	4,650	-1.6%
South Africa	-40	45	793	-5.1%	2,690	-1.5%
Netherlands	22	36	729	3.0%	2,540	0.9%
Singapore	-33	45	-149	-21.9%	1,410	-2.3%

All figures in millions of \$ unless otherwise stated