Appendix to Trade Costs, CO2, and the Environment

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A Data Appendix

A.1 Transport Modes

I use a few general rules to compile the transportation data. I exclude observations with unknown trading partners or products. I convert all foreign currencies to US dollars using the mean period exchange rate from the IMF's International Financial Statistics, then deflate values to the year 2007 using the US Bureau of Labor Statistics Consumer Price Index. Where possible, I use importer reports. When a trade flow reports currency but not weight, I impute weight using the mode-specific weight-to-value ratio from all other countries reporting transportation modes. If a landlocked country reports trade by sea, I measure the sea distance according to the population-weighted distance from its trading partner.

Some decisions are specific to each data source. For EU trade, I treat "inland waterway" trade as maritime trade. For US imports, I sum freight charges and product values to obtain the goods' value. Japan only distinguishes transport mode for airborne and container ship trade, so I assign additional Japanese trade values (obtained from the same Trade Statistics of Japan source) to sea shipment. I use the HS-to-sector concordance file described below to link these HS codes to the sectors I analyze.

I obtain EU data at the 2-digit HS code level, so I use the procedure described below for the Australian freight data. In mapping 2-digit trade data to the sectors I analyze, I apply value shares to the trade value data and weight shares to the trade weight data.

I impute transportation mode shares for the remaining 17-26 percent of international trade, and for intranational trade, I use fractional multinomial logit. Let x_{od} denote the covariates used to impute mode shares. x_{od} includes 11 variables: log importer and exporter GDP per capita and their squares, log bilateral distances by air and by sea and their squares, and dummy variables identifying landlocked, contiguous, and island countries. For predicting intranational mode shares, I use only contiguous countries, since these reflect the much greater proportion of rail and road shares for nearby transportation.

In a fractional multinomial logit, the share of the o-d trade flow transported by mode m is

$$\sigma_{odm} = \begin{cases} \frac{1}{1+\sum_{\tilde{m}=2}^{M} \exp(x_{od}\gamma_{\tilde{m}})} & \text{if } m = 1 \\ \frac{\exp(x_{od}\gamma_m)}{1+\sum_{\tilde{m}=2}^{M} \exp(x_{od}\gamma_{\tilde{m}})} & \text{if } m > 1 \end{cases} \tag{A.1}$$

One mode is arbitrarily chosen as the base category $m = 1$. The corresponding log likelihood for observation odm is

$$\ln(L_{odm}) = \sum_{\bar{m}=1}^{M} \ln(\tilde{\sigma}_{od\bar{m}})\, \sigma_{od\bar{m}} \tag{A.2}$$

where $\tilde{\sigma}_{odm}$ represents the fitted value from (A.1).

I use a secondary reference to impose mode shares in one case—UNECA (2010, p. 214) reports that 80 percent of intra-African freight transportation moves by road. I impose this statistic on all intra-African trade, then estimate the division of remaining trade between sea, rail, and air using equation (A.2). Cristea, Hummels, Puzzello and Avetisyan (2013) make a similar adjustment.

For Assumption 3 in the main text, I impute weight-to-value ratios (W) for the quarter of world trade where weight is missing. Using data from global trade, I measure W separately for each of the 13 tradable sectors and 4 observed transport modes, then apply these values to the missing data.

A.2 Freight Costs

The Australian and US data have similar general structure. In the raw Australian data, there is an observation for each combination of an exporter, 2-digit Harmonized System code, quarter, and year. The Australian data report the value of goods separately at their port of origin and port of destination. I define the shipping cost as the difference between these values. In the raw US data, there is an observation for each combination of an exporter, 10-digit Harmonized System code, month, and year. The US data report the charges for insurance and shipping for each observation. I define the US shipping cost as these charges divided by the value of the goods at their US port of entry. The value at their US port of entry (i.e., the CIF value) equals the reported value of the goods plus the reported charges for insurance and shipping.

I use a few rules to compile the Australian and US data. I exclude the few observations where shipping costs are negative, or outlying observations where the shipping cost exceeds the goods' value (which represent about a tenth of a percent of the aggregated data). For both importers, I exclude observations which list the exporter as unknown or where the exporter is not a country. I use a quarterly price deflator for these data from the Bureau of Labor Statistics Consumer Price Index. I do not use US files from four months which had corrupted data in two independent sets of files I checked: April 2003, February 2004, August 2008, and

May 2010.

For both the US and Australian data, the shipping cost s used in regressions equals the total shipping cost reported for an exporter-quarter-sector, divided by the total value of shipments for this trade flow. This measure is equivalent to a trade-flow weighted average across the various months, industries, and countries that comprise and exporter-quarter-sector.

Defining the sectors in these data requires constructing one concordance file for the US data and a separate concordance file for the Australian data. The US data use different revisions of the Harmonized Commodity Description and Coding System (HS) codes (1992, 1996, 2002, and 2007). I construct a concordance file which links HS codes from each revision to the sectors I analyze. For the 2002 revision, I use a dataset created by Thomas Hutcheson as part of the Global Trade and Analysis Project (GTAP) which links each 6-digit HS code to the sectors I analyze. For the 2007 HS revision, I invert a 2002-to-2007 concordance which the UN Statistics Division created, and I then apply the 2002 concordance described above. For the 1996 HS revision, I use a concordance file created by Robert McDougall and Mark Gehlhar as part of GTAP. For the 1992 revision, I invert the UN's 1992-to-1996 HS concordance file then apply the 1996 concordance described above. I find 21 6-digit HS codes which appear in the US trade data but not in this concordance file. I assign these codes to a sector based on the concordance for the same code in a different HS revision, or based on the assignment of adjacent HS codes. By inverting the 2002-to-2007 concordance file, for the few cases where one year 2007 code links to multiple year 2002 codes, I uniquely link it to the first 2002 code ordered numerically. I use the same procedure to invert the 1992-to-1996 HS concordance file. Unclassified trade (HS=999999) are mapped to the "Other" sector.

The Australian data are only available at the 2-digit HS code level. To link these data to the sectors I analyze, I construct a concordance linking each year of the Australian data to a sector. Using 6-digit HS code trade value data from each year of UN-Comtrade (a source which reports trade value and weight but not mode) for Australian imports only, for each HS code-by-trading partner-by year cell, I measure the share of value which falls in each of the sectors I analyze. I then apply these shares to the Australian data.

The Rauch (1999) classification of homogenous, reference-priced, and differentiated goods is defined in terms of SITC Revision 2 codes. To estimate trade elasticities according to this classification, I use concordances published by the UN Statistics Division for all four HS revisions which link 6-digit HS codes to SITC Revision 2 codes. I use this approach to define all the US trade data in SITC Revision 2 codes. I apply the same approach I use for the main data to define the Australian shipping cost data in terms of the three Rauch categories.

In the freight cost data and in the calculation of fuel costs for the counterfactual analyses, I winsorize freight and fuel costs at 100 percent of product values to address outliers. In the counterfactual analyses, this affects a twentieth of a percentage point of observations.

A.3 Trade and Production Data

To calculate value-added (GDP) by country and sector from the GTAP data, I sum the value of payments to all factors together with total taxes (McDonald and Thierfelder 2004). I exclude taxes devoted to producing capital goods, since these are not assigned to individual sectors. I measure gross output in cost including insurance and freight terms (CIF; equivalently, I measure it at world prices) so gross output is comparable with international exports in the model, which are described in CIF terms. I winsorize country-by-sector value-added (GDP) data at 1.5 and 98.5 percent of gross output. Similarly, I winsorize Cobb-Douglas expenditure shares at one percent and scale expenditure shares for other sectors so they sum to one for each country. These each affect a handful of observations with outlying values. I combine the "Rest of the World" and "Other Oceania" countries. Gross output equals value added (GDP) plus the value of intermediate goods. Total domestic purchases (X_{oo}) are calculated as gross output minus international exports. Some results distinguish three groups of countries by GDP per capita, which equals national GDP divided by national population, as reported in the GTAP data.

A.4 Other Data for CO2 Emissions from Trade

The data sources recording the mode of transportation also record weight-to-value ratios (W). These data report the total value and quantity of each trade flow, but not all quantities represent weights. I aggregate over the transportation mode datasets to obtain weight-to-value ratios used to fill in missing data (see the Appendix).

Fuel efficiency (ξ_{odm}, measured in gCO_2/ton-km) for air and sea shipping is measured from published data as follows. For airborne trade, data on global ton-km and global fuel consumption imply a fuel economy for air freight of 985.97 gCO_2/ton-km (IATA 2009). Because airplanes form atmospheric contrails which warm the climate, many scientists estimate that airplanes contribute 1.5 to 3.0 times more to climate change than their CO_2 emissions would imply. For simplicity, I follow most policymakers in measuring airplanes' climate change impact according to their CO_2 emissions. For maritime trade, the CO_2 emissions due to international transportation (IEA 2011) and the international ton-km reported by the shipping industry imply fuel efficiency for sea freight of 9.53 gCO_2/ton-km.[1] This approach is not possible for rail and road shipping because I know of no data on total global fuel consumption for these transport modes. Instead, I compare across estimates in the trans-

[1] For air, IATA reports a global air fuel economy of 39.0 liters/ton-km. I convert this to gCO_2 using the US Energy Information Agency's reference rate of 9.57 kg CO_2 per gallon of jet fuel. For sea, IEA (2011) reports that international marine transportation emitted 624.5 $MtCO_2$. Freight accounts for 90 percent of civilian ship CO_2 emissions (IMO 2009, p. 160) and the IEA international maritime data generally exclude military ship emissions (Reece 2004). Dividing CO_2 emissions of 562.05 $MtCO_2$ by the 50.6 trillion ton-km of international freight reported to be traded by ship gives the 11.11 rate.

portation literature, each representing a specific region. This approach leads to fuel economy estimates of 23.0 gCO_2/ton-km for rail and 119.0 gCO_2/ton-km for road (Appendix Table 1). I impose a fuel consumption rate (ξ) of zero for the “other” transportation mode.

I use estimates of the CO_2 emissions from production compiled by GTAP. GTAP uses the “Tier 1” method of the Intergovernmental Panel on Climate Change (IPCC 1997) to compile these data.[2] For each sector and country in the year 2007, these data report the tons of CO_2 emitted by producing the good. I use the GTAP data because it provides extensive country and sector detail. Among ways of estimating CO_2 emissions, the Tier 1 method has the lowest data requirements and simplest methodology—it generally multiplies physical quantities of fuel consumption by mean emissions coefficients. GTAP obtains these data from input-output matrices and national accounts for each country.

A.5 Additional Cleaning

In all datasets, I exclude observations where the partner country cannot be identified (e.g., “Africa,” "areas not elsewhere specified," etc.). For calculating damages from the Regional Integrated Climate-Economy (RICE) model, I include Mozambique and Tanzania in the Africa region, and I combine Western Sahara with Morocco.

For commodity-specific data, I exclude observations with commodity codes that are missing or that do not correspond to Harmonized System values.

The preceding sections described the concordance of the 13 tradable sectors in this paper to Harmonized System codes. The 13 sectors represent the following groupings of GTAP sector codes (Version 8): 1 to 14 (Agriculture, Forestry); 15 to 18 (Mining); 19 to 26 (Food, Beverages, Tobacco); 27 (Textiles); 28 and 29 (Apparel, Leather); 30 (Wood); 31 (Paper, Printing); 32 and 34 (Petroleum, Coal, Minerals); 33 (Chemicals, Rubber, Plastics); 35 to 37 (Metals); 40 to 41 (Machinery, Electrical); 38 to 39 (Transport Equipment); 42 (Other).

A.6 Climate Damages

The social cost of carbon value \$29 for the year 2007 linearly extrapolates the Interagency estimates of \$32 for the year 2010 and \$37 for the year 2015. Cai, Judd and Lontzek (2012) report several possible values of the social cost of carbon. I take the value \$200 from their Figure 8 because it reflects a risk aversion parameter consistent with the literature they cite

[2] The IPCC describes three methods (“Tiers”) of calculating greenhouse gas emissions from economic activity. The Tier 1 method assigns a greenhouse gas emissions coefficient to each physical unit of fossil fuel, then multiplies this coefficient by the physical units of each fossil fuel used directly to produce output in a given sector of a country. The Tier 2 method uses country-specific emission factors and other data. The Tier 3 method uses sector- or country-specific models. This study uses Tier 1 data because they are what is comparable and available for all countries and sectors with industry classificatoin and time period that matches the rest of this paper.

(i.e., ten or smaller), it allows for tipping points, and it conservatively reflects the maximum possible value of the uncertain damage parameter among values they consider.

I use estimates from the RICE model (Nordhaus and Boyer 2000) to calculate each region's climate damages as follows. Nordhaus and Boyer's calculate the damage due to a 2.5°C warming for each of 13 regions, expressed as a portion of GDP, as follows: US 0.45%, China 0.22%, Japan 0.50%, OECD Europe 2.83%, Russia -0.65%, India 4.93%, Other High Income -0.39%, High Income OPEC 1.95%, Eastern Europe 0.71%, Middle Income 2.44%, Lower-middle Income 1.81%, Africa 3.91%, and Low Income 2.64%. These values clearly abstract from calamitous possibilities in some countries—some island nations, for example, may lose significant shares of their land mass due to global sea level rise and flooding. This is, however, the most comprehensive set of estimates available. Denoting this damage for a region as d_r, I measure a country's proportion of global climate damages as $\frac{d_r G_r}{\sum_r d_r G_r}$. So for a global marginal social cost of carbon of \$19.96, I choose μ_d so that in the baseline, a one-ton increase in carbon emissions decreases indirect utility for countries in region r by $19.96 \frac{d_r G_r}{\sum_r d_r G_r}$.

The functional form in assumption A1 does not allow for benefits from climate change, whereas in the Nordhaus and Boyer data, eight country-regions are projected to benefit from climate change: Australia, Canada, Hong Kong, Israel, New Zealand, Singapore, Russia, and the Rest of Europe. In the year 2007, these countries accounted for 3.6 percent of global population and 7.7 percent of global GDP. The Rest of Europe is an aggregated country which combines Andorra, Bosnia and Herzegovina, Faroe Islands, Gibraltar, Guernsey, Vatican City, Isle of Man, Jersey, Macedonia, Monaco, Montenegro, San Marino, and Serbia. For consistency with the standard quadratic damage function, I assume that each of these country-regions has zero damage from climate change.

B How Reasonable are these Trade Elasticities?

I evaluate the estimates of trade elasticities with a simple test: theory predicts that demand should be more elastic for more homogenous goods. I find that the pattern of elasticities across sectors is consistent with this theoretical prediction.

I implement this test using data from Rauch (1999), who separates traded goods into three classifications: goods traded on listed exchanges ("homogenous"); goods with reference prices; and all other goods ("differentiated"). Rauch classifies nearly all traded goods by product based on several printed volumes listing prices.

This test provides sensible results (Appendix Table 2). All three types of goods have strong instruments, with first stage F-statistics between 26 and 90. Differentiated goods have the smallest trade elasticity in absolute value (-5.75), and homogenous goods have the largest elasticity (-9.18). Although theoretical predictions for reference-priced goods are less clear, those goods have an intermediate elasticity of -5.81. Statistically, all three elasticities are significantly different from zero, though the three estimates have overlapping confidence regions. Table 3 reports the "conservative" classification of Rauch (1999), which minimizes the number of commodities classified as homogenous or reference priced. Using Rauch's "liberal" classification, which maximizes those numbers, obtains estimates (and standard errors) of -7.26 (2.37), -4.61 (1.58), and -10.5 (1.89) for the differentiated, reference-priced, and homogenous goods, respectively.

Existing estimates in the literature for the global economy or for manufacturing generally lie in the range -4 to -10 (Anderson and van Wincoop 2004). My estimate of $\theta = -7.33$ for manufactured goods lies in this range. My sector-by-sector range of estimates vary somewhat from other estimates at similar aggregation levels. My most homogenous sector has an elasticity of only -18.56, whereas Caliendo and Parro (2015) find elasticities of -51 to -69. My most differentiated sector has an elasticity of -1.55, which is more negative than Caliendo and Parro's -0.37.

C Comparison to Estimates by International Organizations

This paper describes detailed measures of CO_2 emissions from shipping for nearly a million specific trade flows. It is useful to evaluate these estimates by comparing them against independent sources which provide coarser measures of CO_2 emissions but which can therefore use simpler data and methods.

The totals implied by these data are close to totals of these published sources. For example, the EU collected data from every airline landing or departing in the EU about their fuel consumption in order to plan for the inclusion of airplane CO_2 emissions in the EU cap-and-trade system. I estimate total air freight CO_2 emissions involving the EU of 75.3 $MtCO_2$, while the European Commission (2011) implies a value of 78.9 $MtCO_2$. To provide another comparison, I measure total sea freight of 7,900 tons, whereas UNCTAD (2009) provides an estimate of 7,882 tons. Overall, my estimates of total air freight emissions from the EU, total air freight emissions globally, total sea CO_2, and total sea tons shipped are close to the estimates of international organizations. My estimates for international air freight, international air ton-km, and sea ton-miles are slightly larger than the estimates of international organizations. This suggests that my detailed data replicate the global stylized facts about these forms of shipping.

Several assumptions are required to compare my estimates of air and sea CO_2 emissions to the estimates of international organizations. For air travel, the global organization for airlines (IATA 2009) reports that all air transportation moved 498.7 billion ton-km in 2007 and that 167.7 billion of this represented freight. (The remainder is mail, passengers, and passenger baggage.) So globally, 33.6 percent of air transportation ton-km represents freight.

The EU air estimate is calculated as follows. To add air transportation to the ETS, the EU collected data indicating that in the years 2004 to 2006, flights to and from the EU emitted an annual mean of 221.4 $MtCO_2$. Applying the 0.336 freight/transportation ratio described above implies annual EU air freight emissions of 74.61 $MtCO_2$. Applying the 5.7 percent 2005-2007 growth in international air transportation CO_2 emissions (IEA 2011) implies an EU-reported total of 78.86 $MtCO_2$.

The IEA calculates its international air estimate as follows. The IEA reports that international air transportation emitted 431 $MtCO_2$ in the year 2007. Assuming again that 33.6 percent of this represents freight, we have an IEA estimate for air freight of 145 $MtCO_2$.

The ICAO total air estimate is calculated as follows. The ICAO (2009) estimates that domestic and international aviation emitted a total of 632 $MtCO_2$ in the year 2006. I inflate this by the 2006-2007 5 percent growth in global air ton-km reported by IATA (2009), then multiply by the IATA freight/total ton-km ratio of 0.336 to obtain an ICAO estimate of 223 $MtCO_2$ for international plus domestic air freight.

D Inference

This section describes the methodology for bias-corrected bootstrap estimates of the 95-percent confidence intervals for counterfactual calculations. This bootstrap takes $B = 200$ draws of the 13×1 vector θ from the 13 independent normal distributions that have mean and standard deviation given by the instrumental variables parameter estimates and standard errors of Table 2, columns 7-8. If any element of the bth draw $\theta(b)$ is positive and so economically infeasible, I re-draw the $\theta(b)$ vector until I obtain negative values. This procedure consistently estimates the true confidence interval under the null hypothesis that $\theta^j < 0$. For each draw $\theta(b)$, I calculate the model's estimate $\zeta(b)$ of the parameter of interest. $\zeta(b)$ for different table entries represents welfare, international trade, or pollution.

Given these draws, I report the bias-corrected bootstrap estimate of the 95-percent confidence region, which can provide an accurate finite-sample approximation (Efron 1987). The bootstrap estimate of the confidence region is given by the pair $(\zeta^{(\alpha_1)}, \zeta^{(\alpha_2)})$, where $\zeta^{(\alpha)}$ denotes the 100$\cdot\alpha$th percentile of the B estimates $\zeta(1), \ldots, \zeta(200)$. The unadjusted percentiles for the 95-percent confidence interval are $\alpha_1 = 0.025$ and $\alpha_2 = 0.975$. The bias-corrected percentiles are

$$\begin{aligned} \alpha_1 &= \Phi\left(2z_0 + z^{(\alpha)}\right) \\ \alpha_2 &= \Phi\left(2z_0 + z^{(1-\alpha)}\right) \end{aligned}$$

Here $\Phi(\cdot)$ represents the standard normal cumulative distribution function (CDF) and $z^{(\alpha)}$ represents the 100$\cdot\alpha$th percentile of a standard normal CDF. The bias correction coefficient

z_0 is calculated from the share of bootstrap estimates $\zeta(1), \ldots, \zeta(200)$ which are less than the full-sample estimate ζ:

$$z_0 \equiv \Phi^{-1}\left(B^{-1}\sum_{b=1}^{B} 1[\zeta(b) < \zeta]\right)$$

Here $1[\cdot]$ represents the indicator function, which takes the value one if its argument is true and zero otherwise, and $\Phi^{-1}(\cdot)$ represents the inverse of a standard normal CDF.

E Welfare Effects of Climate Change Regulation

I use the following algorithm to assess welfare under counterfactual policies:

1. Choose an initial candidate vector of wage changes $\hat{w}_d$ for all countries.

2. Given the candidate wage vector $\hat{w}_d$ at an iteration of the algorithm, estimate the vector of price changes $\hat{p}_d^j$ by iterating over the equation $\hat{p}_d^j = (\hat{w}_d)^{\beta_d^j}(\hat{p}_d^j)^{1-\beta_d^j}$. This step reflects the contraction map algorithm of Alvarez and Lucas (2007).

3. Given these candidate values of $\hat{w}_d$ and $\hat{p}_d^j$, new trade and production $X_{od}^{j'}$ are given by equation (E.1). As shown below the trade and production decisions $X_{od}^{j'}$ can be calculated as a function of the parameters θ^j, the data $(\lambda_{od}^j, T_o^j, \beta_o^j, \alpha_o^j)$, the chosen carbon taxes t_{od}^j, and the recovered wage and price changes $\hat{w}_d$ and $\hat{p}_d^j$.

4. Check whether the resulting values $(X_{od}^{j'}, t_{od}^{j'}, T_d^{'})$ satisfy the equilibrium market clearing condition (6b). If not, adjust the candidate values of $\hat{w}_d$ and return to step 2.

5. Once the equilibrium values of $\hat{w}_d$ are found in step 4, substitute the new values of $X_{od}^{j'}/p_{od}^{j'}$ into equation (5) to determine new carbon dioxide emissions $E_d^{'}$ from each country.

6. Using the equations described in section 2.2, substitute values of $\widehat{I}_d$, $\widehat{P}_d$, E_o, and $E_o^{'}$ into equation (7) to measure the change in social welfare for each country.

Measuring the effect of climate change regulations requires calculating $X_{od}^{j\prime}$ as a function of $\hat{w}_d$ and known data. I calculate $X_{od}^{j\prime}$ from

$$X'(\hat{w}_d) = [I - F(\hat{w}_d)]^{-1}\Psi(\hat{w}_d) \tag{E.1}$$

To explain these matrices, I begin with three terms which are easiest to derive. The budget constraint, trade balance, and gravity equation imply the following three equations:

$$\hat{c}_o^j = (\hat{w}_d)^{\beta_d^j} (\hat{p}_d^j)^{1-\beta_d^j}$$

$$\hat{p}_d^j = \left[\sum_{o=1}^{N} \lambda_{od}^j (\hat{c}_o^j \hat{\tau}_{od}^j)^{\theta^j}\right]^{1/\theta^j} \tag{E.2}$$

$$\hat{\lambda}_{od}^j = \left(\frac{\hat{c}_o^j \hat{\tau}_{od}^j}{\hat{p}_d^j}\right)^{\theta^j} \tag{E.3}$$

These relationships represent the proportional effect of a regulation on production costs, prices, and trade flows.

I now turn to explain the main calculation. X' is an $NJ \times 1$ vector representing expenditures after a carbon tax is imposed. As in the main text, x' represents the value of the variable x after a regulation is imposed, and no vectors or matrices in this section are transposed. The vector X' is ordered by country then sector, so that the first 14 entries represent the values for the first country; the second 14 entries represent values for the second country, etc. I is an $NJ \times NJ$ identity matrix. $\Psi(\hat{w}_d)$ is an $NJ \times 1$ vector defined as follows:

$$\Psi(\hat{w}_d) \equiv \alpha_d^j \hat{w}_d (w_d L_d) - (1-\beta_d^j) T_d^j + \alpha_d^j T_d$$

Finally, the $NJ \times NJ$ matrix $F(\hat{w}_d)$ is the sum of four separate $NJ \times NJ$ matrices:

$$F = A + B + C + D$$

These four matrices are defined as follows, where $G_{od} = 1$ if the importer receives the tariff revenue and $G_{od} = 0$ otherwise:

$$\begin{aligned} A &= diag\left((1-\beta_d^j)\sum_{o=1}^{N} \frac{\lambda_{od}^{j\prime}}{1+t_{od}^j}\left[1+t_{od}^j(1-G_{od})\right]\right) \\ &= \begin{bmatrix} \left(1-\beta_1^1\right)\sum_o \frac{\lambda_{o1}^{1\prime}\left[1+t_{o1}^1(1-G_{o1})\right]}{1+t_{o1}^1} & & & 0 \\ & \left(1-\beta_1^2\right)\sum_o \frac{\lambda_{o1}^{2\prime}\left[1+t_{o1}^2(1-G_{o1})\right]}{1+t_{o1}^2} & & \\ & & \ddots & \\ 0 & & & \left(1-\beta_N^J\right)\sum_o \frac{\lambda_{oN}^{J\prime}\left[1+t_{oN}^J(1-G_{oN})\right]}{1+t_{oN}^J} \end{bmatrix} \end{aligned}$$

$$
\begin{aligned}
B &\equiv diag\left(\begin{bmatrix} \rho_d^{j,k=1} & \dots & \rho_d^{j=1,k=J} \\ \vdots & \ddots & \vdots \\ \rho_d^{j=J,k=1} & \dots & \rho_d^{j=K,k=J} \end{bmatrix}\right) \\
&= \begin{bmatrix} \begin{bmatrix} \rho_{d=1}^{j=1,k=1} & \dots & \rho_{d=1}^{j=1,k=J} \\ \vdots & \ddots & \vdots \\ \rho_{d=1}^{j=J,k=1} & \dots & \rho_{d=1}^{j=K,k=J} \end{bmatrix} & & 0 \\ & \ddots & \\ 0 & & \begin{bmatrix} \rho_{d=N}^{j=1,k=1} & \dots & \rho_{d=N}^{j=1,k=J} \\ \vdots & \ddots & \vdots \\ \rho_{d=N}^{j=J,j=1} & \dots & \rho_{d=N}^{j=J,k=J} \end{bmatrix} \end{bmatrix} \\
\rho_d^{j,k} &= \alpha_d^j \sum_{o=1}^{N} \frac{t_{od}^k G_{od}^k \lambda_{od}^{k\prime}}{1+t_{odj}}
\end{aligned}
$$

$$
\begin{aligned}
C &\equiv \left(\alpha_o^j \frac{t_{od}^k \left(1-G_{od}^k\right) \lambda_{on}^{k\prime}}{1+t_{od}^k}\right) \\
&= \begin{bmatrix} \alpha_1^1 \frac{t_{11}^1\left(1-G_{11}^1\right)\lambda_{11}^{1\prime}}{1+t_{11}^1} & \dots & \alpha_1^1 \frac{t_{11}^J\left(1-G_{11}^J\right)\lambda_{11}^{J\prime}}{1+t_{11}^J} & \dots & \alpha_1^1 \frac{t_{1N}^J\left(1-G_{1N}^J\right)\lambda_{1N}^{J\prime}}{1+t_{1N}^J} \\ \vdots & & \vdots & & \vdots \\ \alpha_1^J \frac{t_{11}^1\left(1-G_{11}^1\right)\lambda_{11}^{1\prime}}{1+t_{11}^1} & \dots & \alpha_1^J \frac{t_{11}^J\left(1-G_{11}^J\right)\lambda_{11}^{J\prime}}{1+t_{11}^J} & \dots & \alpha_1^J \frac{t_{1N}^J\left(1-G_{1N}^J\right)\lambda_{1N}^{J\prime}}{1+t_{1N}^J} \\ \vdots & & \vdots & & \vdots \\ \alpha_N^J \frac{t_{N1}^1\left(1-G_{N1}^1\right)\lambda_{N1}^{1\prime}}{1+t_{N1}^1} & \dots & \alpha_N^J \frac{t_{N1}^J\left(1-G_{N1}^J\right)\lambda_{N1}^{J\prime}}{1+t_{N1}^J} & \dots & \alpha_N^J \frac{t_{NN}^J\left(1-G_{NN}^J\right)\lambda_{NN}^{J\prime}}{1+t_{NN}^J} \end{bmatrix}
\end{aligned}
$$

$$
\begin{aligned}
D &= \begin{bmatrix} \begin{bmatrix} D_{11}^1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & D_{11}^J \end{bmatrix} & \begin{bmatrix} D_{12}^1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & D_{12}^J \end{bmatrix} & \begin{bmatrix} D_{1N}^1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & D_{1N}^J \end{bmatrix} \\ \vdots & \ddots & \vdots \\ \begin{bmatrix} D_{N1}^1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & D_{N1}^J \end{bmatrix} & \dots & \begin{bmatrix} D_{NN}^1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & D_{NN}^J \end{bmatrix} \end{bmatrix} \\
D_{od}^j &= \left(1-\beta_d^j\right)\left[t_{od}^j\left(1-G_{od}\right)\right]\frac{\lambda_{od}^j}{1+t_{od}^j} X_d^j
\end{aligned}
$$

These matrices can be derived by solving the budget constraint after a regulation is imposed in order to obtain X' as a function of other parameters and variables of the model.

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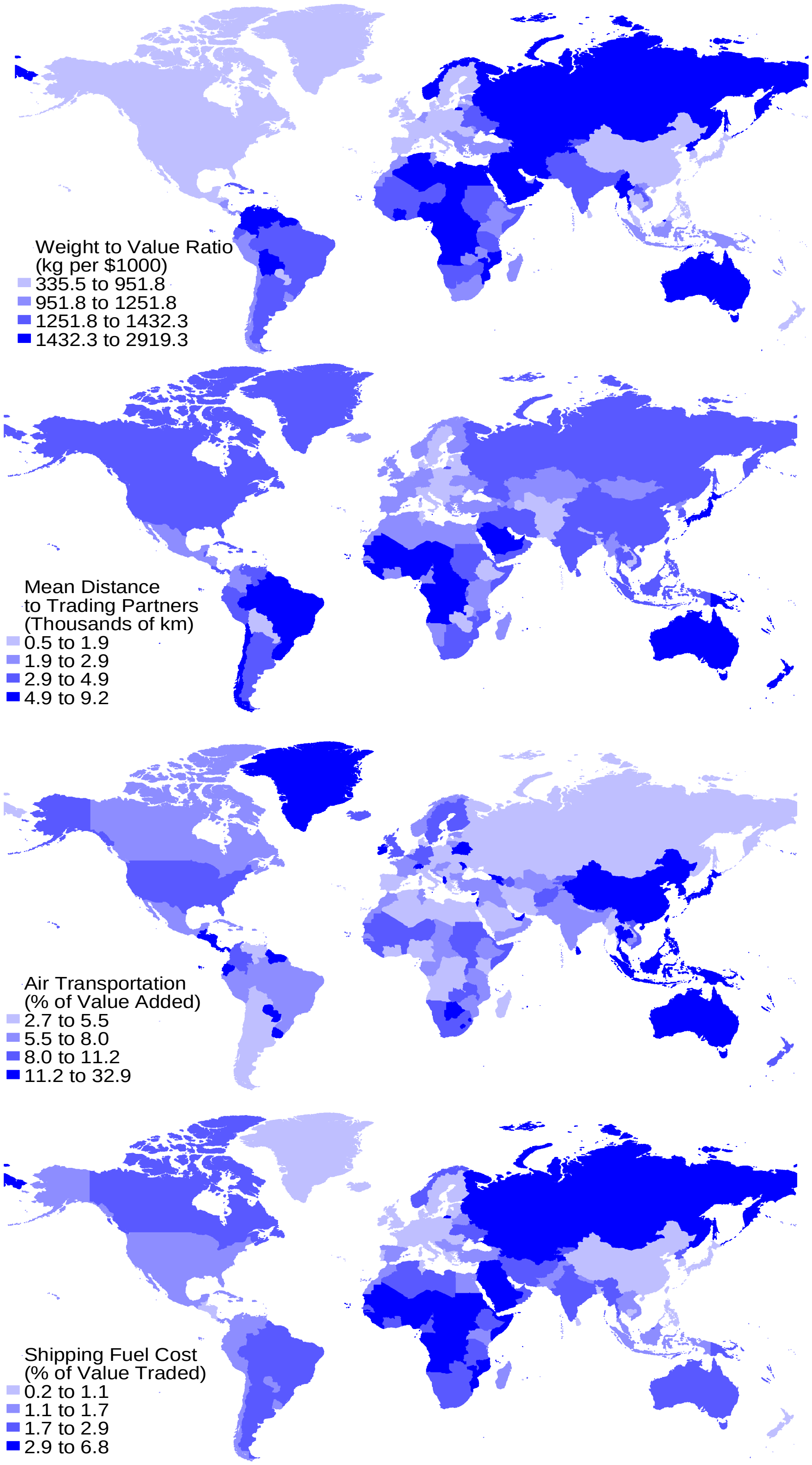

Appendix Figure 1: Shipping Fuel Intensity of Traded Goods

Notes: Data aggregate over intranational trade, international imports, and international exports. Mean distance is weighted by kg. Fuel cost is calculated by equation (3c).

Appendix Table 1: Review of Fuel Economy Estimates, by Transportation Mode (gCO2/Ton-km)

Mode	Value (gCO_2/ton-km)	Method	Region	Source
Air	985.97	Fuel consumption divided by ton-km	Global	This paper, IATA (2009)
Air	540	n.a.	Boeing 747	NTM (2012)
Air	912 to 963.45	Calculations from published data	US	Cristea et al. (2011)
Air	595-1916	Engineering estimates	UK	Defra (2009)
Sea	9.53	Global CO_2 emissions from IEA (2011) divided by original ton-km freight estimates	Global	This paper
Sea	4.5 to 16.3	Engineering estimates aggregated over ship fleet registeries	Global	Psaraftis and Kontovas (2009)
Sea	15 to 21	n.a.	n.a.	NTM (2012)
Sea	4 to 20	Engineering estimates	UK	Defra (2009)
Rail	23	Summary of studies listed below	Global	This paper
Rail	23	n.a.	Asia	ADB (2010)
Rail	22.7	n.a.	EU15	Giannouli et al. (2006)
Rail	7.3 to 26.3	Literature review	EU	Cefic (2011)
Rail	27.6	Fuel consumption divided by freight transport	UK	ORR (2009)
Rail	10-119	Literature review	Various	IMO (2009)
Road	119	Summary of studies listed below	Global	This paper
Road	119.7	n.a.	EU	Giannouli et al. (2006)
Road	61	n.a.	Asia	ADB (2010)
Road	118.6	Fuel consumption divided by freight transport	UK	Defra (2009)
Road	80-181	Literature review	Various	IMO (2009)
Other	0	Assumption	Global	This paper

Notes: n.a.=not available.

Appendix Table 2: Trade Elasticities, by Rauch (1999) Classification

	Log Shipping Costs (FS)	Log Import Shares (IV)	N
	(1)	(2)	(3)
Differentiated	0.26***	-5.75**	4,750
	(0.05)	(2.66)	
Reference Priced	0.38***	-5.81**	4,104
	(0.04)	(2.40)	
Homogenous	0.36***	-9.18***	3,374
	(0.07)	(2.86)	

Notes: See notes to Table 2.

Appendix Table 3: Trade Elasticities, Instrumental-Variables Estimates, Sensitivity Analysis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agriculture, Forestry	-3.431	-4.777***	-2.461	-3.264	-3.015	-0.031	-9.602*	-2.086**
	(2.182)	(1.806)	(2.850)	(3.139)	(2.072)	(3.163)	(5.519)	(0.992)
Mining	-3.212*	-2.405	-1.153	-3.263*	-2.943*	-3.338**	-2.96	-1.940***
	(1.723)	(1.513)	(1.808)	(1.952)	(1.648)	(1.685)	(2.087)	(0.616)
Food, Beverages, Tobacco	-7.180**	-6.709	-8.771**	-8.141*	-6.719**	-5.202	-5.309***	-4.765***
	(3.323)	(4.124)	(3.545)	(4.388)	(3.070)	(4.362)	(1.776)	(0.888)
Textiles	-24.102***	-13.987***	-27.589***	-24.441**	-21.505***	-34.455***	-17.437***	-7.041***
	(7.549)	(4.610)	(10.128)	(9.897)	(6.472)	(11.989)	(4.963)	(0.885)
Apparel, Leather	-6.328**	-9.757***	-7.754**	-7.915**	-5.988**	-14.039***	-9.533***	-4.335***
	(2.618)	(2.984)	(3.012)	(3.644)	(2.425)	(3.876)	(3.231)	(0.903)
Wood	-6.067***	-7.259*	-8.077**	-5.383*	-5.712***	-6.981***	-7.661***	-1.898***
	(2.137)	(4.074)	(3.185)	(2.911)	(2.003)	(2.371)	(2.504)	(0.575)
Paper, Printing	-4.792	-3.838	-4.703	-5.234	-4.572	-4.129	-4.572	-1.194***
	(3.398)	(4.614)	(5.864)	(4.554)	(3.084)	(3.341)	(4.233)	(0.442)
Petroleum, Coal, Minerals	-8.612***	-12.256***	-6.064*	-9.994*	-7.855**	-10.583***	-6.480**	-3.512***
	(3.171)	(4.087)	(3.291)	(5.659)	(3.019)	(3.444)	(3.106)	(0.769)
Chemicals, Rubber, Plastics	-5.514**	-2.444	-3.666	-5.471*	-3.930**	-5.774*	-2.573	-4.090***
	(2.454)	(2.523)	(3.088)	(2.933)	(1.946)	(3.029)	(3.615)	(0.920)
Metals	-13.849**	-21.824**	-13.356**	-16.721**	-12.135**	-16.876***	-12.846	-5.354***
	(6.135)	(10.597)	(6.772)	(8.224)	(5.253)	(6.450)	(12.314)	(0.735)
Machinery, Electrical	-11.042***	-4.516	-20.173**	-11.785***	-8.797***	-12.346***	-10.597***	-7.325***
	(2.978)	(5.525)	(7.772)	(3.815)	(2.200)	(3.246)	(3.648)	(0.701)
Transport Equipment	-6.429	-10.355	-12.045*	-7.656	-5.336	-6.720	-3.56	-4.551***
	(5.508)	(6.433)	(7.118)	(8.651)	(4.626)	(6.138)	(2.915)	(0.913)
Other	-6.692*	-8.215	-16.818**	-7.350	-6.916*	-8.254**	-16.712**	-3.301***
	(3.769)	(8.546)	(7.373)	(4.855)	(3.623)	(4.102)	(6.922)	(0.547)
Mean Across Sectors	-8.250	-8.334	-10.202	-8.971	-7.340	-9.902	-8.449	-3.953
Correlation with Table 2, Col. 4	0.85	0.70	0.89	0.87	0.88	0.88	0.88	0.65
Quarters 1,4 instrument quarters	Yes	No	No	No	No	No	No	No
Quarters 1,2 instrument quarters	No	Yes	No	No	No	No	No	No
GLS weights	No	No	Yes	No	No	No	No	No
log(x+0.00001)	No	No	No	Yes	No	No	No	No
Include tariffs in shipping cost	No	No	No	No	Yes	No	No	No
Control separately for tariffs	No	No	No	No	No	Yes	No	No
Full year FE estimates	No	No	No	No	No	No	Yes	No
Cross sectional estimates	No	No	No	No	No	No	No	Yes

Notes: The data include two importers: the US and Australia. Columns (5) uses log(1+s+k) as explanatory variable, where k is tariff rate reported in US and Australian data. Each table entry represents a separate regression. "Correlation with Table 2" reports the correlation coefficient between the 13 sector-specific elasticities reported in a given column of this table and the 13 elasticities reported in Table 2, column 4. An observation represents a good-exporter-importer-year. Cross-sectional estimates include origin FE, destination FE, and year FE only. All standard errors clustered by importer-exporter pair. *** $p<0.01$, ** $p<0.05$, * $p<0.10$.

Appendix Table 4. Sensitivity to Model Assumptions, Full Welfare Effects of International Trade (Billions of US$)

Model	Gains from Trade (1)	Environmental Costs of Trade (2)	Change in Welfare (3)	Change in Welfare (Percentage Points): Richest (4)	Middle (5)	Poorest (6)
1. Main results	5,359	-59	5,389	9	11	14
2. Social Cost of CO_2=$11/ton	5,359	-22	5,371	9	11	14
3. Social Cost of CO_2=$77/ton	5,359	-156	5,439	9	11	14
4. Proportional Climate Damages	5,359	-59	5,390	9	11	14
5. Social Cost of CO_2=$200/ton, Proportional Climate Damages	5,359	-404	5,567	9	11	15
6. Trade Elasticity = -4.14	4,483	-59	4,517	8	8	12
7. Trade Elasticity = -8.28	2,305	-62	2,353	4	4	6
8. Trade Elasticities: AT 3, Column 1	3,121	-60	3,165	6	5	8
9. Trade Elasticities: AT 3, Column 2	4,290	-60	4,329	7	8	11
10. Trade Elasticities: AT 3, Column 3	4,893	-58	4,929	9	8	11
11. Trade Elasticities: AT 3, Column 4	2,963	-60	3,008	5	5	7
12. Trade Elasticities: AT 3, Column 5	3,614	-60	3,655	6	6	9
13. Trade Elasticities: AT 3, Column 6	13,168	-51	13,189	22	26	31
14. All Domestic Mode Shares from CFS	5,359	-105	5,430	9	11	14

Notes: See paper text for additional details on each row. Columns (1) through (3) are in US$ billions. "AT 3" refers to Appendix Table 3. Columns (4)-(6) separate countries into three groups of 42-43 countries based on 2007 GDP per capita. The GDP per capita ranges defining each group are: above $14,000; $2,400 to $14,000; and below $2,400.

Appendix Table 5. Sensitivity to Model Assumptions, Carbon Taxes (Billions of US$)

			Change in Welfare					
						Basis Points		
	Gains from Trade	Environmental Costs of Trade	Global	EU	US	Richest	Middle	Poorest
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: EU Carbon Tax for Air Shipping								
1. Main Results	-2.90	-3.80	0.90	28.70	-7.20	0.34	-0.76	-1.57
2. SCC=$11	-0.11	-0.31	0.20	4.54	-1.04	0.06	-0.13	-0.25
3. SCC=$77	-2.90	-10.08	7.18	32.15	-6.72	0.45	-0.67	-1.29
4. Proportional Climate Damages	-2.90	-4.12	1.22	27.93	-6.40	0.35	-0.73	-1.66
5. SCC=$200, Proportional Damages	-12.05	-51.00	38.95	75.92	-5.54	1.44	-0.98	-3.26
6. Trade Elasticity = -4.14	-2.15	-2.83	0.68	31.97	-7.66	0.39	-0.92	-1.70
7. Trade Elasticity = -8.28	-3.07	-3.94	0.87	28.71	-7.48	0.34	-0.78	-1.53
8. Trade Elasticities: AT 3, Column 1	-2.92	-3.77	0.85	28.03	-7.38	0.32	-0.71	-1.51
9. Trade Elasticities: AT 3, Column 2	-3.09	-4.04	0.95	30.51	-7.47	0.36	-0.83	-1.55
10. Trade Elasticities: AT 3, Column 3	-2.84	-3.59	0.75	25.52	-7.29	0.29	-0.59	-1.47
11. Trade Elasticities: AT 3, Column 4	-3.06	-3.97	0.90	27.76	-7.36	0.32	-0.70	-1.48
12. Trade Elasticities: AT 3, Column 5	-2.76	-3.58	0.83	29.07	-7.40	0.34	-0.76	-1.56
13. Trade Elasticities: AT 3, Column 6	-2.97	-3.89	0.93	27.85	-7.30	0.32	-0.68	-1.53
14. All Domestic Mode Shares from CFS	-0.60	-1.85	1.25	11.98	-2.69	0.16	-0.30	-0.60
15. Endogenous Mode Share Shifts	-2.90	-3.41	0.51	28.48	-7.24	0.33	-0.76	-1.58
16. Detailed Inter-Industry Links	-0.45	-0.86	0.40	4.38	-0.88	0.06	-0.11	-0.23
Panel B: US Carbon Tax for All Shipping								
1. Main Results	-2.38	-9.33	6.95	-1.17	30.15	0.46	-0.77	-1.20
2. SCC=$11	-0.36	-1.39	1.03	-1.70	12.12	0.16	-0.33	-0.56
3. SCC=$77	-14.96	-60.73	45.77	17.88	69.08	1.58	-1.42	-1.39
4. Proportional Climate Damages	-2.38	-10.12	7.74	-3.06	32.13	0.48	-0.72	-1.43
5. SCC=$200, Proportional Damages	-80.91	-377.53	296.56	86.46	198.98	6.84	1.65	-2.57
6. Trade Elasticity = -4.14	-2.35	-9.06	6.70	-1.01	29.23	0.45	-0.76	-1.18
7. Trade Elasticity = -8.28	-2.70	-10.24	7.54	0.04	20.05	0.34	-0.36	-0.80
8. Trade Elasticities: AT 3, Column 1	-2.40	-9.38	6.98	-0.73	28.86	0.45	-0.73	-1.17
9. Trade Elasticities: AT 3, Column 2	-2.37	-9.63	7.26	0.46	22.25	0.37	-0.43	-1.11
10. Trade Elasticities: AT 3, Column 3	-2.30	-9.08	6.78	-2.07	36.01	0.54	-1.03	-1.36
11. Trade Elasticities: AT 3, Column 4	-2.42	-9.48	7.07	-0.56	28.31	0.44	-0.71	-1.15
12. Trade Elasticities: AT 3, Column 5	-2.36	-9.20	6.84	-0.73	29.26	0.46	-0.75	-1.23
13. Trade Elasticities: AT 3, Column 6	-2.40	-9.06	6.66	-0.82	32.13	0.50	-0.87	-1.43
14. All Domestic Mode Shares from CFS	-5.25	-23.02	17.77	2.97	13.34	0.35	0.17	0.47
15. Endogenous Mode Share Shifts	-2.38	-9.33	6.95	-1.17	30.15	0.46	-0.77	-1.20
16. Detailed Inter-Industry Links	-12.77	-3.37	-9.40	-0.37	0.47	-0.10	-0.37	-0.41
Panel C: Global Carbon Tax for Air & Sea Shipping								
1. Main Results	-6.53	-16.71	10.18	18.00	3.47	0.53	-0.72	-1.29
2. SCC=$11	-1.05	-2.60	1.55	5.25	1.08	0.16	-0.31	-0.61
3. SCC=$77	-36.77	-100.76	63.98	72.57	12.64	2.02	-1.43	-1.51
4. Proportional Climate Damages	-6.53	-18.13	11.60	14.61	7.02	0.57	-0.62	-1.69
5. SCC=$200, Proportional Damages	-168.85	-567.36	398.34	204.45	158.79	9.65	1.54	-7.07
6. Trade Elasticity = -4.14	-5.81	-14.55	8.74	17.90	1.96	0.56	-0.85	-1.65
7. Trade Elasticity = -8.28	-9.04	-21.01	11.97	19.54	1.17	0.54	-0.61	-1.24
8. Trade Elasticities: AT 3, Column 1	-6.51	-16.55	10.04	17.17	3.08	0.50	-0.64	-1.18
9. Trade Elasticities: AT 3, Column 2	-6.64	-17.14	10.50	20.17	2.54	0.56	-0.88	-1.02
10. Trade Elasticities: AT 3, Column 3	-5.14	-14.12	8.98	12.72	3.52	0.40	-0.42	-1.01
11. Trade Elasticities: AT 3, Column 4	-6.78	-17.20	10.42	17.38	2.99	0.50	-0.64	-1.09
12. Trade Elasticities: AT 3, Column 5	-6.11	-15.73	9.62	17.60	3.26	0.52	-0.73	-1.28
13. Trade Elasticities: AT 3, Column 6	-6.55	-16.85	10.30	17.34	4.03	0.50	-0.61	-1.23
14. All Domestic Mode Shares from CFS	-6.61	-14.86	8.24	18.44	5.30	0.55	-0.96	-1.30
15. Endogenous Mode Share Shifts	-6.53	-17.83	11.30	18.61	3.55	0.55	-0.70	-1.24
16. Detailed Inter-Industry Links	-37.60	-7.68	-29.93	0.96	-2.82	-0.35	-1.00	-1.35

Notes: Numbers represent total effects over a decade. Columns (1) through (5) represent billions of 2007 US$. "AT 3" refers to Appendix Table 3. Columns (6)-(8) separate countries into three groups of 42-43 countries based on 2007 GDP per capita. The GDP per capita ranges defining each group are: above $14,000; $2,400 to $14,000; and below $2,400.

Appendix Table 6. Country-by-Country Estimates

	Gains from International Trade ($Bn)	Environmental Costs of International Trade ($Bn)	Welfare Change in Basis Points due to . . .		
			EU Regulation	US Regulation	Global Regulation
	(1)	(2)	(3)	(4)	(5)
Albania	1.80	-0.01	-0.62	-1.87	-1.98
Argentina	24.84	-0.25	-0.77	1.08	-6.18
Armenia	1.67	-0.01	-0.59	-1.18	-0.29
Australia	68.36	0.00	-1.39	-0.43	-4.86
Austria	63.67	-0.41	1.36	0.17	0.40
Azerbaijan	10.12	-0.03	-2.08	6.12	6.53
Bahrain	3.17	-0.01	-1.35	1.81	1.02
Bangladesh	10.51	-0.07	-1.57	-1.34	0.62
Belarus	16.32	-0.01	0.73	0.41	4.81
Belgium	299.15	-0.51	2.99	-0.85	2.55
Bolivia	3.32	-0.01	-0.96	0.42	2.72
Botswana	4.73	-0.02	-11.98	0.96	-9.17
Brazil	56.99	-1.27	-0.24	0.25	-3.49
Bulgaria	13.67	-0.01	1.26	-1.94	0.90
Cambodia	2.81	-0.01	-2.79	-5.37	-8.37
Cameroon	1.73	-0.03	-1.91	0.81	-1.05
Canada	141.12	0.00	-0.66	-2.52	0.37
Caribbean	23.70	-0.25	-0.71	-1.25	1.40
Chile	19.59	-0.12	-1.94	0.66	1.22
China	320.93	-0.29	-0.89	-1.07	-0.22
Colombia	18.76	-0.14	-0.74	-0.71	-1.62
Costa Rica	6.30	-0.02	-4.30	-0.93	-0.50
Cote D Ivoire	2.79	-0.03	-2.41	3.61	4.29
Crotia	13.23	-0.02	-0.25	-1.84	-0.50
Cyprus	3.83	-0.02	0.00	-3.03	-2.57
Czech Republic	45.86	-0.05	2.66	0.03	1.25
Denmark	33.83	-0.35	0.98	0.00	0.86
Ecuador	16.21	-0.03	-2.27	-0.90	-2.85
Egypt	25.49	-0.13	-0.97	-3.87	1.49
El Salvador	16.92	-0.01	-0.95	-5.06	0.67
Estonia	8.46	-0.01	0.39	-1.78	-1.99
Ethiopia	2.34	-0.03	-1.60	-1.54	-1.82
Finland	34.00	-0.27	1.68	0.34	1.17
France	239.11	-2.93	1.17	-0.04	0.61
Georgia	3.29	-0.01	-0.98	-2.19	-1.17
Germany	342.36	-3.70	2.57	0.49	1.60
Ghana	5.08	-0.04	-1.94	-0.95	0.88
Greece	40.58	-0.35	-0.06	-1.84	-1.08
Guatemala	7.62	-0.04	-1.39	-3.76	-0.48
Honduras	3.55	-0.01	-2.03	-9.40	-3.05
Hong Kong	69.41	0.00	-2.67	-2.94	-2.04
Hungary	31.60	-0.04	2.72	-0.37	1.24
India	93.03	-2.32	-0.62	-0.24	1.67
Indonesia	33.93	-0.44	-2.24	-0.24	-2.25
Iran	32.20	-0.20	-0.66	1.22	-3.11
Ireland	22.28	-0.29	3.40	1.99	3.27
Israel	28.17	0.00	-0.73	-2.60	0.44
Italy	213.92	-2.37	1.34	0.04	1.21
Japan	351.48	-0.85	0.00	-0.77	1.51
Kazakhstan	16.88	-0.07	-1.83	1.37	1.82
Kenya	8.45	-0.04	-2.95	-1.26	0.53
Korea	134.53	-1.00	-0.35	-1.03	3.07
Kuwait	13.63	-0.09	-6.78	1.40	-33.79
Kyrgyzstan	2.10	0.00	-1.03	-2.50	-1.81
Laos	2.07	0.00	-9.16	0.25	-3.49

Appendix Table 6. Country-by-Country Estimates

	Gains from International Trade ($Bn)	Environmental Costs of International Trade ($Bn)	Welfare Change in Basis Points due to . . .		
			EU Regulation	US Regulation	Global Regulation
	(1)	(2)	(3)	(4)	(5)
Latvia	6.50	-0.01	-0.13	-1.96	-2.02
Lithuania	11.42	-0.01	0.50	-1.40	0.10
Luxembourg	12.30	-0.06	1.29	-0.14	-0.08
Madagascar	0.94	-0.01	-5.93	-0.89	-3.02
Malawi	1.04	-0.01	-9.44	-3.28	-9.33
Malaysia	25.27	-0.17	-3.40	-3.29	0.51
Malta	3.48	-0.01	0.73	-4.65	-3.26
Mauritius	1.19	-0.01	-15.23	-2.53	-6.23
Mexico	109.18	-0.72	-0.39	-4.79	1.08
Mongolia	1.17	0.00	-5.38	1.60	15.28
Morocco	11.39	-0.05	-1.06	-4.01	0.59
Mozambique	1.99	-0.01	-7.01	-2.32	-3.37
Namibia	2.32	-0.01	-9.65	-1.22	-7.19
Nepal	1.40	-0.01	-0.49	-1.02	-1.02
Netherlands	54.45	-0.87	1.78	0.93	2.16
New Zealand	12.67	0.00	-1.70	-0.02	-0.99
Nicaragua	2.58	-0.01	-2.43	-6.27	-1.60
Nigeria	20.08	-0.25	-1.65	-2.56	-13.45
Norway	30.84	-0.43	1.30	1.57	1.60
Oman	8.80	-0.03	-3.14	1.33	-0.02
Pakistan	19.34	-0.15	-0.73	-1.21	0.27
Panama	4.27	-0.01	-1.68	-10.27	-5.31
Paraguay	6.29	-0.01	-0.89	-1.90	0.97
Peru	9.16	-0.08	-1.29	1.20	0.57
Philippines	28.04	-0.15	-0.76	-1.86	1.72
Poland	70.52	-0.12	0.73	-0.59	0.40
Portugal	36.44	-0.26	1.00	-0.76	0.60
Qatar	5.16	-0.06	-1.65	1.05	-3.68
Rest of Central Africa	4.61	-0.06	-5.75	-2.55	-22.15
Rest of Central America	0.41	0.00	-4.37	-1.95	-3.22
Rest of East Asia	2.49	-0.03	-1.15	-0.81	-1.08
Rest of Eastern Africa	5.63	-0.09	-1.07	0.15	1.87
Rest of Eastern Europe	2.68	0.00	-1.06	-3.51	-2.27
Rest of EFTA	3.51	-0.03	1.35	-1.16	-0.36
Rest of Europe	17.07	0.00	-0.77	-1.91	-1.32
Rest of Fmr. Soviet Union	12.95	-0.04	-3.51	4.31	-1.08
Rest of North Africa	32.66	-0.15	0.73	3.26	2.66
Rest of North America	1.38	-0.01	-1.70	-2.55	-2.67
Rest of Oceania	5.00	-0.02	-4.04	-0.07	-1.71
Rest of SACU	0.23	-0.01	-10.14	0.27	-5.95
Rest of South America	1.43	-0.01	-8.40	-1.82	-6.01
Rest of South Asia	3.20	-0.01	-2.50	-2.24	-1.37
Rest of South Central Africa	12.29	-0.10	-4.08	-7.66	-40.70
Rest of Southeast Asia	7.35	-0.03	-2.89	0.52	-2.53
Rest of Western Africa	8.09	-0.06	-1.88	-5.68	-5.24
Rest of Western Asia	43.87	-0.14	-3.33	-3.45	-5.76
Romania	28.16	-0.05	0.31	-1.34	-0.40
Russian Federation	90.23	0.00	-1.00	1.06	-1.56
Saudi Arabia	36.04	-0.29	-4.04	0.26	-22.74
Senegal	1.99	-0.02	-2.58	-1.36	1.67
Singapore	53.52	0.00	-2.24	-1.51	10.38
Slovakia	22.70	-0.02	1.96	-0.39	1.56
Slovenia	12.56	-0.01	0.98	-0.60	-0.20
South Africa	33.12	-0.20	-3.10	-0.26	0.46
Spain	170.40	-1.60	1.14	-0.64	0.96

Appendix Table 6. Country-by-Country Estimates

	Gains from International Trade ($Bn) (1)	Environmental Costs of International Trade ($Bn) (2)	Welfare Change in Basis Points due to . . . EU Regulation (3)	US Regulation (4)	Global Regulation (5)
Sri Lanka	4.71	-0.03	-3.64	-2.28	-2.59
Sweden	56.54	-0.51	1.91	0.32	0.84
Switzerland	61.17	-0.48	0.44	0.04	0.42
Taiwan	77.24	-0.38	-2.09	-2.17	4.50
Tanzania	4.84	-0.03	-2.91	-0.64	-0.71
Thailand	48.04	-0.17	-2.15	-1.31	0.69
Tunisia	7.57	-0.02	-0.48	-2.39	0.87
Turkey	74.20	-0.47	-0.27	-1.00	0.59
Uganda	1.69	-0.02	-5.88	0.45	-1.49
Ukraine	59.30	-0.04	-0.14	-1.59	-0.08
United Arab Emirates	39.15	-0.16	-3.16	-1.21	-1.23
United Kingdom	235.92	-3.11	1.54	-0.37	0.57
USA	601.67	-2.46	-0.48	2.01	0.23
Uruguay	5.25	-0.02	-1.64	-0.06	-2.22
Venezuela	17.66	-0.16	-0.40	4.45	-5.42
Viet Nam	32.60	-0.07	-7.03	-3.25	-8.90
Zambia	2.10	-0.02	-8.49	1.99	-3.93
Zimbabwe	1.97	-0.01	-4.97	-0.92	-0.39