

2011

Peter J. Minor
Consulting Economist
Boulder, Colorado USA

Time as a Barrier to Trade: A GTAP Database of *ad valorem* Trade Time Costs

Questions or comments should be directed to the author at PeteMinor@comcast.net

Contents

Acronyms	iii
Introduction	1
Background	2
Paper Overview	3
Creating a Global Database of Time Values	4
Estimates of the Per Day Cost of Time in Trade	4
Time Values and the GTAP Database	5
Two Tier Trade Weighting for a GTAP Database	11
Implementing Time Cost Estimates in GTAP	12
Equations	13
Graphical Representation	13
Doing Business Data-Number of Days to Export and Import	16
GTAP Flex-agg	17
Conclusions	19
References	21
Appendix A	22

ILLUSTRATIONS

Figures

Figure 1 Import Weighted Average Value of the <i>Ad Valorem</i> Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-1)	6
Figure 2 Export Weighted Average Value of the <i>Ad Valorem</i> Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-1)	7
Figure 3 Import Weighted Average Value of the <i>Ad Valorem</i> Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-2)	9
Figure 4 Export Weighted Average Value of the <i>Ad Valorem</i> Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-2)	9
Figure 5 Import Weighted Average Value of the <i>Ad Valorem</i> Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-3)	10
Figure 6 Export Weighted Average Value of the <i>Ad Valorem</i> Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-3)	10
Figure 7 Supply Demand and Welfare Impacts (Partial Equilibrium) of Reducing a Delay in Trade	14

Tables

Table 1 MacMap HS4 Data Base and Correspondence with Hummels' HS4 Time Cost Estimates	6
Table A-1 Missing Values and Per Day Ad Valorem Time Cost Estimates by GTAP Commodity (Tau-1, Tau-2, Tau-3)	20
Table A-2 Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports (Tau-1, Tau-2, Tau-3)	22
Table A-3 Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports(Tau-1, Tau-2, Tau-3)	26

Acronyms

CGE	Computable General Equilibrium
GTAP	Global Trade Analysis Project
HS	Harmonized System
U.S.	United States of America
MacMap	Market Access Maps

Introduction

In recent years there has been increasing emphasis by the international trade community on non-tariff barriers as a significant factor limiting goods trade. Tariffs, subsidies and quotas, the most obvious factors limiting access to international markets are no longer assumed to be the most significant impediment to international goods trade. Regulations and procedures such as customs administration, inspections, trade financing, security issues and infrastructure including ports and roads can cause delays in shipping and are now considered amongst the most significant trade barriers limiting goods trade. Related to these non-tariff factors is the concept of good governance: the efficiency and transparency of processes, contract enforcement and administration. The inclusion of good governance as a topic in international trade analysis is a recognition that no matter how good a trade system looks on paper, or how low official tariffs may be, the system can contain hidden costs. These hidden costs can be direct or indirect. Direct costs of poor governance include bribes and un-official fees. Indirect costs include time delays and uncertainties in delivery resulting from poor administration and infrastructure. Recognizing the importance of non-tariff factors limiting trade, the World Bank Doing Business office has compiled a myriad of statistics and indicators to gauge the importance of these factors in a countries economy and trade¹. Econometricians have been employing gravity type regression models to estimate the costs of these non-tariff barriers and their trade restricting impacts (see Limao and Venables 1999 and Djankov and Freund 2006). Computable general equilibrium (CGE) models, such as GTAP, have been slower to adopt measures of non-tariff barriers and their trade restricting effects. Traditional barriers to trade, including tariffs and quotas, remain the predominant subject of study in these models when considering trade agreements and trade policy. This paper seeks to fill the one gap in data related to indirect time costs resulting from delivery delays into CGE analysis by providing documentation, data and a aggregation tool adapted to the GTAP aggregation program. These data are equally useful for estimating time delays which occur from physical infrastructure as well as administrative delays.

¹ <http://www.doingbusiness.org/>

Background

Empirical evidence of the potential impacts and costs of time in trade include econometric and computable general equilibrium analysis (CGE). Econometrically, Djankov and Freund (2006) demonstrate that a one day delay in trade reduces trade volumes by a significant amount. Hummels (2001) estimated *ad valorem* tariff equivalents of shipping delays. Applying Hummels 2001 methodology to new data on port shipping times, Hummels, Minor and Reisman (2007) provide *ad valorem* per day time costs, by four digit Harmonized Schedule (HS) commodity classification for U.S. imports underscoring that not only does time matter in trade, but the importance (value) of time varies by commodity. So, while time in trade may be modestly important for processed fish, it can be extremely important for electronics or fashion items such as apparel or footwear. Hummels *et al.* 2007 combine time delay cost data with the Doing Business Database² on time delays for crossing international borders and find that reported time delays in the movement of international cargo are frequently more significant than tariffs. Numerous studies have echoed these results through anecdotal evidence, usually through interviews of importers and manufactures. A strong case has, therefore, been made that time delays and speedy delivery matters at least as much as tariff barriers in international trade-perhaps even more. Several authors have proposed that the evolving structure of modern trade suggests a trend of increasing importance for reducing the time delays involved in international trade. Hummels (2001), proposed that as global production becomes increasingly fragmented across countries, timely delivery is becoming increasingly important. Additionally, Hummels asserts that many goods, previously considered standardized, are becoming perishable due to technical or market obsolesces, and their value often depends importantly on timely delivery³.

Utilizing Hummels 2001 estimates, Hertel, Walmsley, and Ikatura (2003) estimate, with a CGE model, the impacts of “new age trade agreements” including provisions to reduce the time and expense of border crossings, in addition to eliminating tariffs and quotas, and find non-trivial impacts arising from the reduction in border crossing times. Building on Hummels *et al.*’s 2007 commodity estimates and Hertel *et al.*’s 2003 methodology, Minor and Tsigas (2008) calculate per day time costs for all commodity and country pairs in GTAP. The advantage of integrating time costs into a CGE’s accounting framework, not practical in the gravity approach, is to the further demonstration of the impacts on economic welfare, and the general equilibrium impacts on production and trade linkages of reducing time delays in the importation and exportation of goods.

² <http://www.doingbusiness.org/MethodologySurveys/>

³ Hummels gives the example of children’s dolls, which have become, in recent years, highly differentiated and fashionable, where knowing which one will sell well during holidays is a major profit center for corporations.

Paper Overview

These early papers noted, the current paper responds to the general need of CGE practitioners and theorists for consistent estimates of the costs of time delays in trade. Specifically, this paper documents a database of per day *ad valorem* time costs for use with the GTAP 7 database. The methodology is based on Minor and Taigas (2008). It also documents a new set of programs which augment the GTAP flex-agg program to produce estimates of the per day *ad valorem* value of time by country and commodity for each of the 113 countries and regions and 57 sector in version 7 of the GTAP database. Finally, a graphical illustration of welfare impacts arising from time delays is presented in a partial equilibrium model to illustrate the theoretical basis of how time values can be implemented in a CGE model, such as GTAP.

Creating a Global Database of Time Values

The creation of a global database of per day *ad valorem* time values in trade estimates requires three steps. First, a set of commodity specific estimates of consumer's and producer's willingness to pay to avoid time delays is employed. In this case, the author relies on estimates created by Hummels *et al.* 2007. Next, the commodity specific values are mapped onto a global database of international trade, to aggregate the detailed commodity specific values to the 57 GTAP sectors and 113 countries and regions. Assumptions used to map these values onto the global database are reviewed. Finally, a brief note on the special two tier aggregation method required in GTAP is discussed.

Estimates of the Per Day Cost of Time in Trade

Hummels (2001) and Hummels *et al.* (2007) estimates the value of time savings by calculating the willingness of purchasers to pay for higher cost air shipping to avoid an additional day of ocean transport. The choice of air versus ocean shipping depends on the benefits and costs of rapid delivery. The benefit is the value the firm or its customers attach to saving a day in transit, while the costs are the higher freight prices for air shipping. The units of these two cost components are different: the relative freight price is measured in terms of the delivered price of the traded goods, while time is measured in days. This requires the conversion of time into *ad valorem* equivalents, or the value of time relative to the cost of the good.

In making this conversion, Hummels (2001) notes that consumers demand less when prices are higher. The decrease in demand when prices increase by one percent is called the *price elasticity of demand*. Balanced against this is the value that consumers attach to getting goods in a more timely fashion ("the benefit of time saving"). The *ad valorem* equivalent for time saving is calculated by combining the estimated price elasticity of demand with the benefit measured in days.

The data for Hummels' estimates come from two sources. The first is the U.S. Merchandise Imports database from 1991–2005. The database reports the monthly values, quantities, and transportation modes of imports, disaggregated by product, by entry point into the United States, and by exporter. The second is a table of shipping times between ports around the world.⁴ From these data Hummels calculates average shipping times between ports in various countries and those in the U.S. It's important to realize, the estimates of time costs, and hence

⁴ "Port2Port Evaluation tool," Fourth Quarter 2006, *ComPair Data, Inc.* www.ComPairedata.com.

demand functions, are derived solely from U.S. trade and transportation data. The user of a global database such as GTAP has to evaluate the relevance of the database estimates, be they behavioral parameters or estimated time costs to any particular country and commodity pair, and these time delay estimates are no exception⁵. Further analysis may extend this work beyond estimates based solely on U.S. data. The results of Hummels' *et al.*'s 2007 estimates are *ad valorem* per day time costs for over 600 HS4 commodities.

Time Values and the GTAP Database

Hummels' HS4 database provides estimates for over 600 commodities, but this number falls short of all HS4 commodities in the GTAP database. Table 1 reports the percentage of missing values resulting from mapping the Hummels HS4 database onto the MacMap 2004 database of trade values⁶. While the Hummels' HS4 data can provide estimates for time costs for 83 percent of world trade based on value weighting, 17 percent of trade value is missing time cost estimates. Missing values arise from a number of sources in Hummels' methodology. As was noted earlier, Hummels estimates are derived from U.S. trade and shipping data, reflecting to some extent the pattern of US trade. This gives rise to several reasons why not all HS4 commodities will be provided a time cost estimate:

- The commodity is exclusively, or nearly exclusively, shipped by surface vessel, resulting in insufficient air freight data to provide an estimate (e.g. oil, wheat, minerals, and lumber)
- The commodity may not be traded in sufficient volume with non-adjacent U.S. trade partners to provide the information required to estimate time costs (Canada and Mexico are excluded from Hummels' estimates, since shipping is almost exclusively by train or truck, not ocean freight, which provides the required estimates of port-to-port shipping times)
- The variation in prices between goods shipped by ocean vessel and airfreight exhibit a high degree of variation, resulting in estimates which cannot be rejected as being significantly different from zero.

Missing values present a problem for users wishing to estimate time values for global trade—i.e., what should the missing values be replaced with? If one is agnostic, and assumes a zero value for the value of time delays, a potential bias is introduced for countries or commodities which might fall into one of the categories listed above (see Tables A-1 through A-3 in the appendix for specific data on missing values by country and commodity).

⁵ Behavioral parameters employed in GTAP are from sample estimates from a subgroup of countries and regions GTAP Resources #2937.

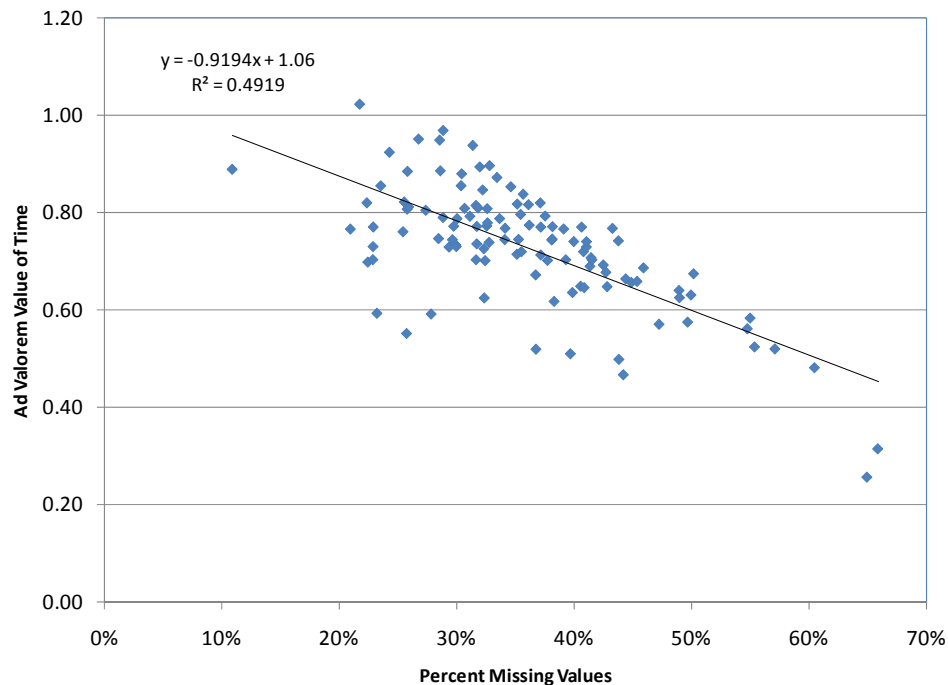
⁶ MacMap 2004 provides the HS6 basis of trade and protection data implemented in the GTAP 7 database. Outlined latter in this paper, another set of trade data are used in the GTAP database at the GTAP country and commodity level, creating a two tier system of trade data which are employed for different levels of analysis. <http://www.cepii.fr/anglaisgraph/bdd/macmap.htm>

Table 1*MacMap HS4 Data Base and Correspondence with Hummels' HS4 Time Cost Estimates*

	Number of Obs.	Value (Millions of Dollars)	Percent	
			Number of Obs.	Value
No Time Cost Estimate	3,724,911	1,504,525	22%	17%
Time Cost Estimate	12,962,253	7,176,976	78%	83%
Total	16,687,164	8,681,501	100%	100%

Source: Author's calculations from MacMap 2004 and Hummels' 2007.

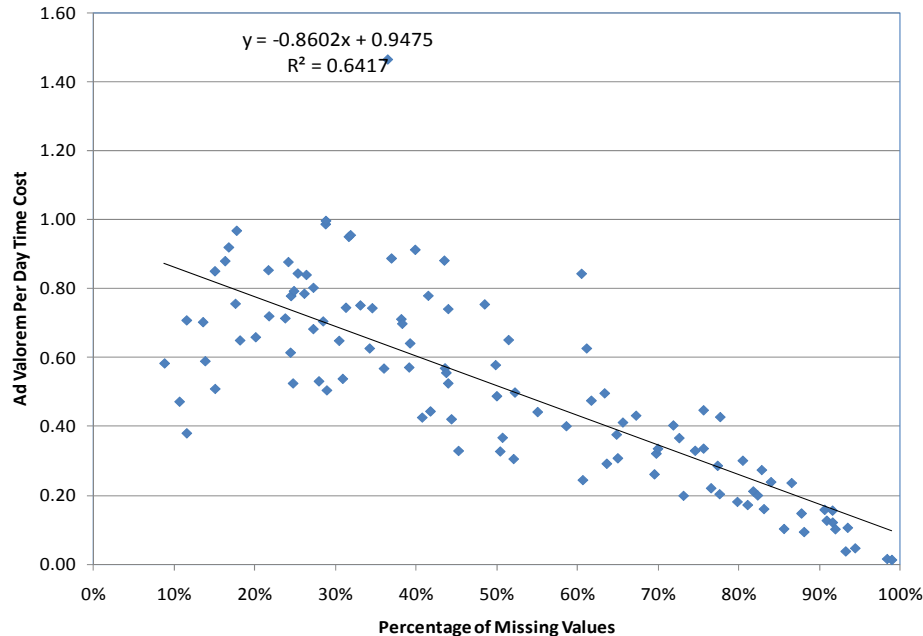
Figures 1 and 2 illustrate a potential bias from replacing missing values with zero values (Tau-1). Figure 1 illustrates the aggregate import weighted average time cost tau-1. Figure 2 reports a similar estimated export weighted average time cost. The vertical access reports the aggregate per day *ad valorem* time cost by country. The horizontal access reports the percentage of missing values by GTAP country and region. A regression line is projected through the observations for illustration purposes. Both figure 1 and figure 2 demonstrate strong negative correlations between missing values and the average per day time cost values. Not surprisingly, as the percentage of missing values increases, the average trade weighted value (tau-1) of time declines as the missing values are replaced with zero values.

Figure 1*Import Weighted Average Value of the Ad Valorem Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-1)***Source: MacMap 2004 and HS4 Value of Time from Hummels 2007.*

*Tau-1 assignment missing and non-significant values of tau equal to zero.

Figure 2

*Export Weighted Average Value of the Ad Valorem Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-1)**



Source: MacMap 2004 and HS4 Value of Time from Hummels 2007.

*Tau-1 assignment missing and non-significant values of tau equal to zero.

To the extent that missing values represent commodity composition e.g. commodities with low time costs are reported as missing and are assigned a zero value, the correlation is somewhat justified. However, there is no *a priori* reason to assume this association at the outset. If missing values represent categories where the U.S. did not have sufficient data to estimate time cost values with confidence, the missing values represent a potential bias when integrating the estimates into global trade databases.

Figures 3 and 4 demonstrate an alternative method (tau-2) for estimating missing *ad valorem* time cost values. In the cases where Hummels' was able to estimate positive point estimates of time cost values, but those values could not be shown to be statistically different from zero, we replace the missing value with the point estimate from Hummels estimation. Again, figures 3 and 4 illustrates the correlation between missing values and the value of time costs, which is not eliminated, but it is reduced when in comparison to figures 1 and 2 with estimate tau-1.

A final global estimate of time costs can be derived by adopting a third method of estimating missing values. Figures 5 and 6 illustrate the time costs by GTAP country and region where missing values are replaced by the average of significant values for a GTAP commodity category (tau-3). The regression line plotted through these points indicates that the previous negative relationship between the percentage of missing values and the average *ad valorem* per

day time cost reverses and becomes positive for exports, e.g., the more missing values, the higher the average value of time costs.

These three scenarios, tau-1, tau-2, and tau-3 provide the theoretical boundaries on the average time costs between low and high. Globally (across all countries and commodities), the average trade weighted time costs range between 0.71 percent per day when missing values are replaced with zeros (tau-1) and 0.89 percent per day when missing values are replaced with the all positive point estimates (tau-2) of time costs to 1.0 percent when missing values are replaced with the average for the GTAP category for positive and significant time cost estimates (tau-3).

The choice of which set of values to employ for a specific analysis is one of appropriateness and may be suggested by further research into the commodity composition of a specific country under consideration. For example, if a country is performing a cost-benefit analysis of significant port and/or customs improvements, a lower and upper bound may be informative when conducting a break even analysis.

In the accompanying database the author provides each of three estimates as outlined in the Flex-agg section of this paper.

Figure 3

Import Weighted Average Value of the Ad-Volrem Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-2)

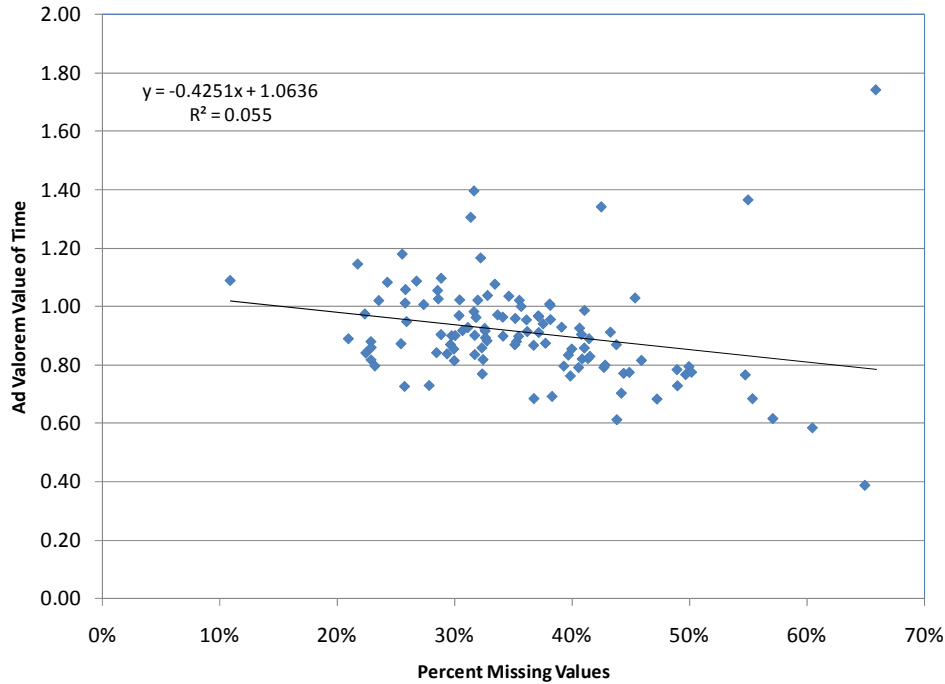


Figure 4

Export Weighted Average Value of the Ad-Volrem Time Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-2)

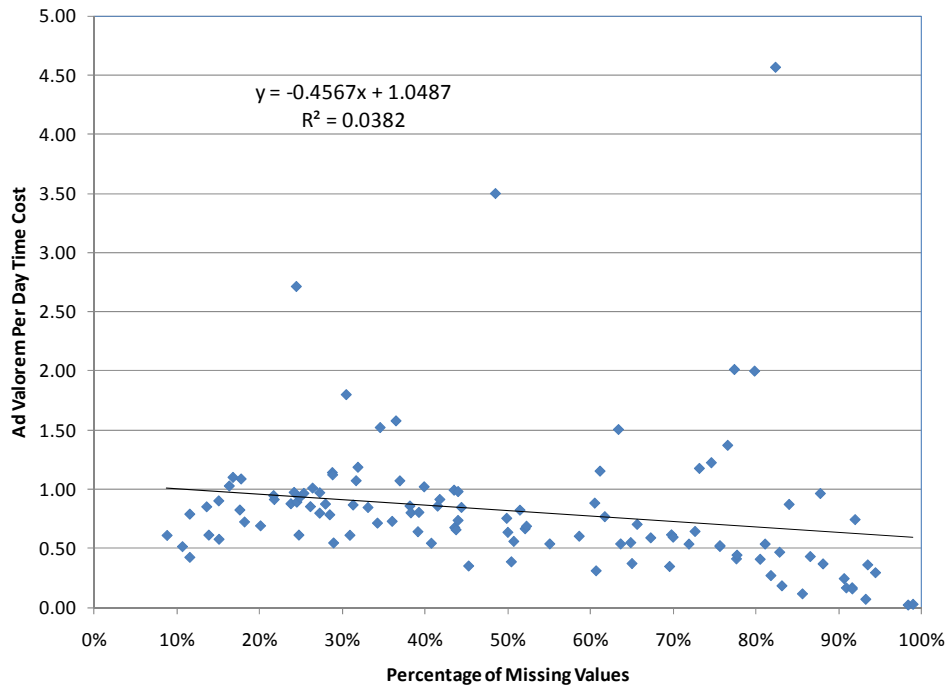


Figure 5

Import Weighted Average Value of the Ad Valorem Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-3)

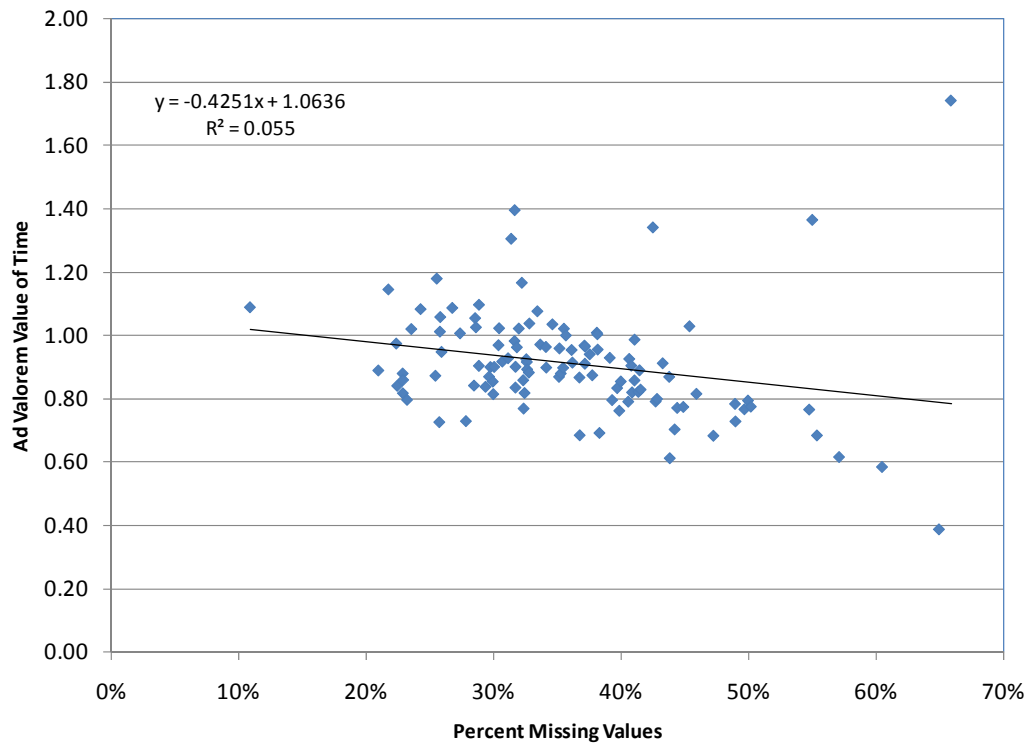
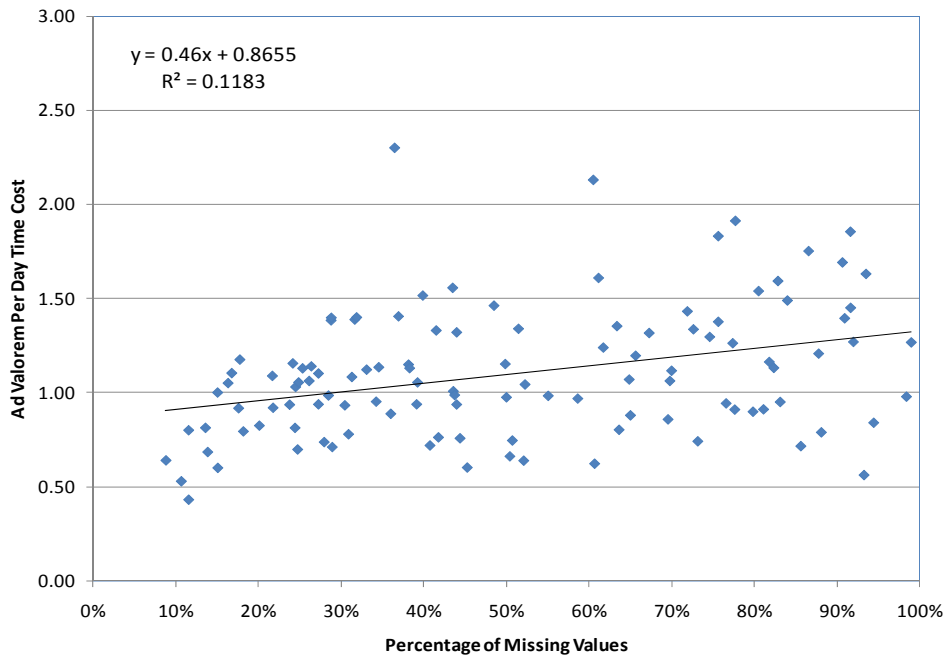


Figure 6

Export Weighted Average Value of the Ad Valorem Per Day Time Cost, by GTAP Region and Percent of Missing Values (Tau-3)



Two Tier Trade Weighting for a GTAP Database

In the prior analysis, HS4 time costs are trade weighted employing the MacMap 2004 database. MacMap 2004 provides trade weights for GTAP protection data at levels of aggregation below the GTAP 57 commodity level (e.g., at the HS4 and HS6 levels). After the GTAP 57 commodity level has been achieved it is possible to weight the time cost values with the trade data contained in the GTAP 7 database. Therefore, creation of the trade weighted values of time for the GTAP 7 database requires a two step procedure: first HS4 time estimates are aggregated to the GTAP commodity and country level utilizing the MacMap 2004 database and second, further aggregation, above the 57 GTAP sectors, must be carried out with GTAP 7 trade data. Horridge (2009) outlines this inconsistency in his construction of TASTE, an application for aggregating trade and protection data for use in GTAP.

Implementing Time Cost Estimates in GTAP

The prior sections reviewed the importance of time costs in trade and outline their estimation. Time costs were provided in *ad valorem* equivalents (percentage of the f.o.b. value of trade) which are comparable to *ad valorem* tariffs. While this comparison of time costs to tariffs is consistent and informative, for CGE modeling purposes (the subject of this paper and the accompanying database), the implementation of tariff costs and time costs are different. Implementation of time costs is a change in consumer preferences—modeled as a shift in the demand curve. In a CGE framework, a shift of the demand curve requires a two part adjustment to the model in order to capture the loss or creation of economic value that is implied by the change in preferences which occurs as a result of consumers obtaining products in a timely manner⁷. This is in contrast to the implementation of a tariff, which is characterized, first, and foremost, as a price wedge characterized as a transfer of value from economic actors to the government and only secondly by lost efficiency in consumption and production.⁸

Hummels (2001) estimates the *ad valorem* equivalent of time delays as a shift in the import demand curve. Hummels' specification of import demand follows that of Armington (1969), which is consistent with the import demand functions used in GTAP. By recognizing that a reduction in the time to import can be represented as a “quality” shift in import demand, one can specify the modification to the GTAP import demand curve. The methodology presented here is based on the work of Hertel *et al.* (2001) and is incorporated in the public release of the GTAP model.

⁷ Hertel *et al.* 2001 refer to this as adjusting the database to maintain consistency.

⁸ While a tariff also can result in losses of efficiency in consumption and production, often the dominating effect is the transfer of value to the government (in the case of a tariff).

Equations

The import demand equation implemented in GTAP is based on total differentiation of the Armington function and its conversion into percentage change form as follows:

$$\text{Equation 1: } qxs_{irs} = -ams_{irs} + qim_{is} - \sigma_m^i(pms_{irs} - ams_{irs} - pim_{is})$$

Following this methodology, the composite price index of imports can be shown to be:

$$\text{Equation 2: } pim_{is} = \sum_r \theta_{irs} pms_{irs} - ams_{irs}$$

Where:

i =the set of traded commodities

r =the set of countries exporting

s =the set of countries importing

qxs_{irs} = is the percentage change in exports of commodity i from region r to region s

qim_{is} = is an index of the percentage change in the quantity demand of
imported commodity i in region s

ams_{irs} = demand shift equal to the ad valorem value of time delays
for commodity i from region r to region s

σ_m^i = the Armington elasticity of substitution for commodity i between all importers m

pms_{irs} = the percentage change in the price of commodity i from region r to region s

pim_{is} = a price index of imported commodity i in region s

θ = the share of commodity i shipped from region r to region s

Following GTAP notation, all lower case variables are percentage changes, and import demand equations are specified in terms of demand for another country's exports. The *ad valorem* equivalent of time enters into both the quantity and price equations to maintain consistency with the database and to introduce the change in value consumers and producers realize from changes in shipping times.

Graphical Representation

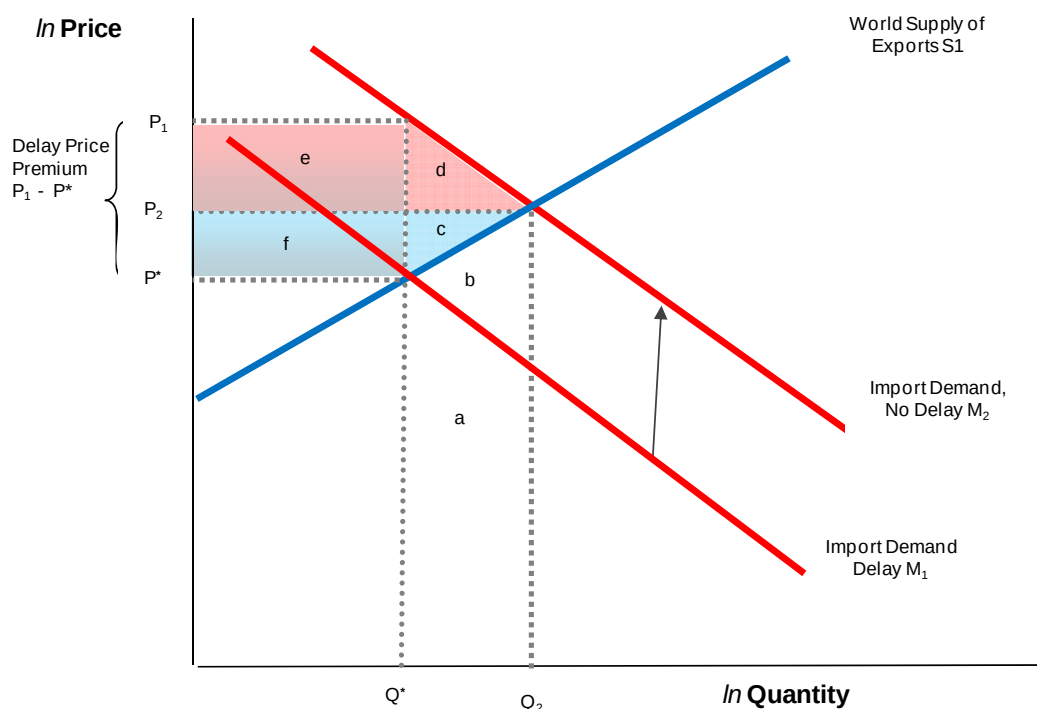
Figure 7 provides a partial equilibrium representation of a reduction in shipping time on import demand and the supply price of exports. For exposition purposes, no tariffs or quotas are included. S_1 is the world supply of the commodity and M_1 is the initial import demand curve. P^* is the initial equilibrium price and Q^* the initial quantity of imports which clears the market. A reduction in international shipping time is introduced, shifting the import demand curve outward from M_1 to M_2 . At the original quantity of export Q^* , Consumers would be

willing to pay P_1 for the imported commodity, a premium of $P_1 - P^*$ equal to the tariff equivalent of time. P_1 is not a market clearing price, there is excess demand in the market. World suppliers of the good increase exports to respond to the new (higher) level of demand, but not without a cost: world prices are bid up to P_2 . This is the terms of trade effect and it will be determined by the factor supplies and behavioral parameters and assumption used in the model. At P_2 , demand has been reduced to clear the market and establish a new equilibrium at P_2, Q_2 .

The welfare impacts include gains in consumer and foreign producer surpluses. In figure 7, areas $a + b$ are equal to the new resources which have to be employed in the production of the increased quantity of goods. Area $f + c$ are the change in foreign producer surplus (increases) and area $e + d$ are the increases in consumer surplus resulting from the reduced trade time delay.

Although a tariff is not represented in figure 7, it would not be hard to introduce the concept into the analysis. If there were an *ad valorem* tariff on the good in question, tariff revenue to the government would unambiguously increase (both price and volume rise) and part of this transfer would reduce both foreign producer and consumer welfare.

Figure 7
Supply Demand and Welfare Impacts (Partial Equilibrium) of Reducing a Delay in Trade



Source: Author's analysis. The Author recognizes the contribution of Dr. David Hummels on the formulation of this representation.

In a CGE model, such as GTAP, welfare is calculated across all products and regions. Huff and Hertel (2000) document the calculation of welfare in GTAP which are consistent with the simple analysis presented in figure 7, but extends the analysis to multiple markets and countries and includes taxes, subsidies and technological change.

Doing Business Data-Number of Days to Export and Import

Estimates of per day time costs can be combined with existing data to estimate tariff equivalents of export and import barriers to trade due to delays in ports, customs administration, and inland transport. The World Bank Doing Business group estimates the number of days delay in trade in their Doing Business-Trading Across Borders Indicator series⁹. The Trading Across Borders data include four indicators of the time to trade across border. These include the number of days required for document handling, inland transport, customs clearance and technical control, and port and terminal handling. These four elements are reported for importing and exporting; resulting in 8 indicators for both imports and exports.

When utilizing the per day time costs of trade, economists focus on what are known as “freight movements”. Freight movements restrict time costs only to activities or delays resulting in delivery times which differ from the baseline. Many activities in the trading processes are undertaken in parallel with other trading activities and hence they do not add to the total time required for delivery. For example, the preparation of import and export documentation can be initiated while goods are in production and can continue while the goods are on the high seas in route to their destination. The user must take special care to account for these parallel time costs which do not impact final delivery time and hence the demand for the good in the destination market.

In the database accompanying this paper, two header files are provided which include the Doing Business Trading Across Border indicators for 2004, the same year as the GTAP v7 database. The headers contain the number of days to import and export. When looking at the aggregation file, the number of days to trade are weighted by the relevant trade flow- the value of exports are utilized to weight time to export and import values are used to weight the time to import.

Several countries included in the GTAP database (explicitly or implicitly in aggregate regions) were not included in the Doing Business Indicators for 2004¹⁰. Missing data were estimated utilizing regional averages for those countries reporting.

<http://www.doingbusiness.org/>⁹

¹⁰ Countries without data include: Cyprus, Luxemburg, Malta, Rest of North America, and Myanmar and Rest of South East Asia.

GTAP Flex-agg

The principal purpose of this paper is to provide documentation on a consistent method of integrating time values into the GTAP framework. The creation of time values is a multi step process requiring at least two sets of data to obtain trade weighted average of time values consistent with GTAP sectors countries or regions. This is similar to the GTAP protection data. In order to facilitate aggregation of time values, consistent with a users choice of commodities and countries, a modified version of GTAP flex-agg was created to reduce the time and effort, and potential errors which might occur in creating measures which are consistent with the aggregation methods employed by GTAP for the creation of other trade protection data.

A user wishing to employ the time cost measures outlined in this paper may download a modified Flex-agg program *aggdatp.exe* and the data file *timev1.har* and place these in their active flex-agg directory¹¹. New aggregations created with these two files in place will result in a modified *gdat.har* output file with three new headers: *TAU*, *DBDI*, and *DBDX*. Within the header *TAU* are the three values for time, *tau1*, *tau2* and *tau3*. Each of these coefficients corresponds to the methods outlined in this paper for replacing missing values.

The *ad valorem* values included in *gdat.har* are the one day *ad valorem* values of time in international trade based on the methodology outlined in this paper. These values may be employed to calculate the *ad valorem* value of time for imports and exports by adjusting the subscript values to correspond to imports or exports and commodity groups in the standard GTAP fashion. Additional calculations may be carried out to provide multi-day time cost estimates, as in the case of Minor and Tsigas (2008).

The headers *DBDI* and *DBDX* include the number of days to import and export as reported by the World Bank Doing Business group for 2004. The headers include the number of days spent in ports, inland transport and customs and technical controls. The number of days to processes documents is not included, since this indicator is not directly related to freight movements.

Users of the time cost data are cautioned to exercise reasonable judgments when multiplying per day *ad valorem* time costs against long time delays. As with any estimate in the GTAP framework, analysis is more reliable when the shocks employed are modest and considered within the context of a specific set of assumptions. As an example, if it takes thirty days to export fresh fruit from a central Asian country to the U.S., the reduction in one day to export may realistically be expected to result in *no* increase in export demand, because twenty-nine

¹¹ Note, the more common windows interface GTAP-agg program is not supported.

days of delay is still prohibitive and the general quality of the fruit after a month or more in transport is still expected to be very low. There are no empirical data to inform the user exactly when time savings become effective (threshold effects) in world markets, just as there are no exact rules to tell us when a tariff becomes prohibitive. It is reasonable to consider average global shipping times, including customs, port dwell and transportation times to identify any extreme situations, as we have indicated in the Central Asian example here.

Conclusions

This paper established the importance of considering the value of time costs in trade. Recent econometric and field experience has demonstrated that time costs likely exceed conventional tariff and quota costs in determining the pattern and volumes of trade. New age trade agreements are being negotiated to include reductions in shipping times between trade partners, in addition to the elimination of tariffs and quotas restricting trade. Hummels 2001 and Hummels *et. al* 2007 provide *ad valorem* estimates of the value of one day of time in trade for U.S. imports. Hummels' estimates the *ad valorem* value of time by comparing detailed shipping time and shipping cost data to a database of airfreight activity and costs. By comparing the costs of airfreight with the time savings, Hummels estimates the willingness of U.S. consumers and producers to pay for the reduction of one day of time in trade.

Hummels' *ad valorem* time cost database fills a much need gap in the GTAP trade and protection data, which emphasizes tariff and quota barriers to trade. However, the mapping of Hummels' time cost data onto the complete GTAP database is not without challenges. Missing values in Hummels analysis are a potential concern when the data are mapped on to a complete set of world trade data. How missing values are treated is a matter of judgment. The author provides three values of *ad valorem* time costs calculated based on three methods for estimating missing values. The first set of estimates (tau-1), includes all positive values of Hummels' HS4 estimates which were significantly different from zero; all missing values of time costs are replaced with zero values. This is an approach which minimizes the average value of time and likely understates time costs, other things being held equal. A second value, tau-2, includes the estimates in tau-1, but also includes all positive values of time costs estimated by Hummels, regardless of their statistical difference from zero. These are still unbiased point estimates of time values and their inclusion reduces the downward bias created by setting non-significant values to zero. On average, there is no reason to assume the point estimates themselves are not normally distributed, that is some will be close to or equal to zero and some will be higher than the point estimate, so while they may not be reliable on an HS4 product level, there is no *a priori* reason to believe they are unreliable when averaged across large product groups. Finally, tau-3, replaces all missing values with the trade weighted average of non-missing values for a GTAP category. Tau-3 results in estimates which are highest, but it makes the use of all known and significant estimates. Overall the globally weighted average values of time vary between 0.71 percent for tau-1, 0.88 percent for tau-2, and 1.0 percent for tau-3.

While Hummels (2000) presents his estimates of time costs as *ad valorem* equivalents which can be readily compared to a countries tariff, the implementation of time costs in a CGE model differs from the implementation of a tariff as a shock in the GTAP model. Moreover, the welfare analysis of time costs is markedly different from a welfare analysis of tariff

changes. Hertel, Walmsley, and Itakura (2001) provide the mathematical implementation of time costs in GTAP. As discussed in this paper, time costs and welfare impacts are best interpreted as a shift in the import demand curve with gains and losses to consumer's and foreign producer's welfare.

Finally, this paper provides a modification of the GTAP flex-agg program and database which facilitates the aggregation of the time cost estimates presented in this paper with the GTAP database. Users are cautioned to use good judgment when employing these estimates in any specific case, but especially when time delays are notably higher than average.

The time cost data presented in this paper fills an important void in the GTAP trade and protection data, which has focused on tariff and quota barriers to trade. Today's global economy is driven less and less by tariff restrictions, and more and more based on timely delivery. Fragmented supply chains and the proliferation of highly differentiated products in more and more sophisticated consumer markets is only increasing the importance of time in trade over traditional trade barriers. This time to trade database fills an important and obvious whole in the GTAP protection database.

References

- Armington, Paul S. 1969. A Theory of Demand for Products Distinguished by Place of Production. IMF Staff Papers 16, (March), pp. 159-178.
- Djankov, Simeon and Freund, Caroline. 2006. Trading on Time. World Bank Policy Research Working Paper 3909.
- Hertel, T., T. Walmsley, and K. Ikatura. 2001. Dynamic Effects of the “New Age” Free Trade Agreement between Japan and Singapore. *Journal of Economic Integration* 24: 1019-1049.
- Horridge, Mark and Laborde, D. 2008. TASTE a Program to Adapt Detailed Trade and Tariff Data to GTAP-Related Purposes. GTAP Resource #2666. Purdue IL.
- Hummels, David. 2001. Time as a Trade Barrier. Purdue University.
<http://www.mgmt.purdue.edu/faculty/hummelsd/research/time3b.pdf>
- Hummels, D., P. Minor, M. Reisman, and E. Endean. 2007. Calculating Tariff Equivalents for Time in Trade. Arlington, VA: Nathan Associates Inc., for the United States Agency for International Development. <http://www.mgmt.purdue.edu/faculty/hummelsd/research/time3b.pdf>.
- Huff, D. and T. Hertel. 2000. Decomposing Welfare Changes in the GTAP Model. GTAP Technical Paper #5. Purdue, Indiana.
- Minor, Peter and Tsigas, M. Impacts of Better Trade Facilitation in Developing Countries: Analysis with a New GTAP Database for the Value of Time in Trade. Mimeo, GTAP resource paper #2762
- Limao, Nuno and Anthony Venables (1999) “Infrastructure, Geographical Disadvantage, and Transport Costs” World Bank Policy Research Working Paper (WPS 2257).

Appendix A

Table A-1

Missing Values and Per Day Ad Valorem Time Cost Estimates by GTAP Commodity (Tau-1, Tau-2, Tau-3)

GTAP Sector	Trade Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Sugar cane, sugar beet	82	--	82	100%	1.47	1.47	1.47
Wearing apparel	202,647	1,904	204,551	99%	0.72	0.72	0.73
Electronic equipment	1,088,662	10,301	1,098,963	99%	0.54	0.54	0.55
Motor vehicles and parts	781,384	103,460	884,844	88%	1.52	1.55	1.72
Machinery and equipment nec	1,229,007	187,446	1,416,453	87%	0.59	0.76	0.68
Metal products	175,075	27,359	202,434	86%	0.80	0.85	0.93
Chemical, rubber, plastic products	1,001,288	225,940	1,227,227	82%	1.09	1.22	1.33
Textiles	223,101	57,788	280,888	79%	0.63	0.70	0.79
Petroleum, coal products	172,131	45,398	217,529	79%	1.58	1.58	1.99
Transport equipment nec	197,445	63,959	261,404	76%	0.61	0.64	0.81
Paper products, publishing	148,939	56,894	205,832	72%	1.45	1.46	2.00
Manufactures nec	118,127	64,545	182,672	65%	0.65	0.67	1.00
Leather products	65,236	37,478	102,714	64%	0.33	0.33	0.51
Mineral products nec	70,751	48,549	119,300	59%	0.96	1.02	1.62
Food products nec	125,414	89,993	215,407	58%	0.94	1.23	1.62
Beverages and tobacco	32,158	48,082	80,240	40%	0.23	0.40	0.57
Wood products	71,312	118,224	189,536	38%	0.19	0.37	0.50
Fishing	5,516	10,943	16,459	34%	0.20	0.20	0.59
Metals nec	65,028	185,919	250,946	26%	0.36	3.11	1.40
Vegetables, fruit, nuts	16,295	65,007	81,302	20%	0.59	0.93	2.94
Ferrous metals	38,522	227,890	266,412	14%	0.28	0.76	1.97
Animal products nec	2,093	17,891	19,984	10%	0.10	1.92	0.93
Meat products nec	3,892	39,254	43,147	9%	0.15	0.15	1.65
Vegetable oils and fats	3,852	43,883	47,735	8%	0.12	0.15	1.51
Crops nec	3,461	40,491	43,952	8%	0.11	0.15	1.45
Forestry	596	14,288	14,884	4%	0.04	0.04	1.00
Bovine cattle, sheep and goats, horses	142	7,064	7,207	2%	0.01	0.01	0.39

Table A-1

Missing Values and Per Day Ad Valorem Time Cost Estimates by GTAP Commodity (Tau-1, Tau-2, Tau-3)

GTAP Sector	Trade Value with Significant Hummels' HS4 Estimate (Millions of US\$)				<i>Ad valorem</i> Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Wool, silk-worm cocoons	38	2,481	2,519	2%	0.01	0.43	0.81
Minerals nec	560	116,014	116,574	0%	0.00	0.25	0.83
Bovine meat products	--	28,858	28,858	--	0.00	0.09	--
Coal	--	37,097	37,097	--	0.00	0.00	--
Electricity	--	27,663	27,663	--	0.00	0.00	--
Oil	--	525,631	525,631	--	0.00	0.00	--
Dairy products	--	45,128	45,128	--	0.00	0.03	--
Oil seeds	--	30,305	30,305	--	0.00	0.64	--
Processed rice	--	9,516	9,516	--	0.00	0.05	--
Cereal grains nec	--	19,665	19,665	--	0.00	0.00	--
Plant-based fibers	--	13,091	13,091	--	0.00	0.00	--
Gas manufacture, distribution	--	6,499	6,499	--	0.00	0.00	--
Gas	--	98,368	98,368	--	0.00	0.00	--
Sugar	--	14,167	14,167	--	0.00	0.02	--
Wheat	--	22,720	22,720	--	0.00	0.00	--
Paddy rice	--	1,596	1,596	--	0.00	0.05	--
Total	5,842,753	2,838,748	8,681,501	83%	0.71	0.89	1.10

Table A-2

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports (Tau-1, Tau-2, Tau-3)

GTAP Country or Region	Import Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Panama	2,544	311	2,855	89%	0.89	1.09	1.00
Mexico	139,887	37,136	177,023	79%	0.77	0.89	0.97
Paraguay	2,553	710	3,264	78%	1.02	1.14	1.31
Costa Rica	6,283	1,812	8,095	78%	0.82	0.97	1.06
Hong Kong	80,828	23,413	104,240	78%	0.70	0.84	0.90
Malta	3,093	918	4,012	77%	0.70	0.88	0.91
Hungary	43,497	12,923	56,420	77%	0.73	0.82	0.95
Ireland	50,948	15,153	66,101	77%	0.77	0.86	1.00
Malaysia	71,862	21,748	93,610	77%	0.59	0.80	0.77
Canada	201,313	62,072	263,385	76%	0.85	1.02	1.12
Argentina	16,325	5,240	21,565	76%	0.92	1.08	1.22
Czech Republic	45,636	15,585	61,221	75%	0.76	0.87	1.02
Australia	73,628	25,290	98,918	74%	0.82	1.18	1.10
Singapore	95,163	33,028	128,191	74%	0.55	0.72	0.74
Cambodia	2,111	735	2,845	74%	0.81	1.01	1.09
Rest of EFTA	3,704	1,291	4,995	74%	0.88	1.06	1.19
Austria	76,609	26,829	103,438	74%	0.81	0.95	1.10
New Zealand	15,436	5,647	21,083	73%	0.95	1.09	1.30
United Kingdom	318,120	120,009	438,129	73%	0.80	1.01	1.11
Philippines	32,733	12,638	45,371	72%	0.59	0.73	0.82
Germany	492,182	196,051	688,233	72%	0.75	0.84	1.04
Guatemala	5,956	2,383	8,340	71%	0.95	1.05	1.33
Slovenia	12,364	4,963	17,327	71%	0.89	1.02	1.24
France	304,509	123,604	428,113	71%	0.79	0.90	1.11
Cyprus	4,189	1,701	5,890	71%	0.97	1.10	1.36
Sweden	66,928	27,857	94,785	71%	0.73	0.84	1.03
Tunisia	9,438	3,982	13,419	70%	0.74	0.87	1.06
Denmark	43,288	18,355	61,643	70%	0.77	0.90	1.10
United States of America	969,708	414,873	1,384,581	70%	0.73	0.85	1.05
Slovakia	19,227	8,241	27,467	70%	0.73	0.81	1.04
Kyrgyzstan	1,113	479	1,592	70%	0.79	0.90	1.13

Table A-2

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports (Tau-1, Tau-2, Tau-3)

GTAP Country or Region	Import Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Rest of Southeast Asia	1,097	479	1,576	70%	0.85	0.97	1.23
Luxembourg	12,523	5,485	18,008	70%	0.88	1.02	1.26
Poland	57,284	25,385	82,668	69%	0.81	0.92	1.17
Spain	170,751	77,295	248,046	69%	0.79	0.93	1.15
Bolivia	1,357	621	1,979	69%	0.94	1.30	1.37
Viet Nam	20,075	9,306	29,380	68%	0.81	0.98	1.19
Switzerland	80,399	37,287	117,686	68%	0.70	1.40	1.03
Romania	21,877	10,173	32,049	68%	0.74	0.83	1.08
Russian Federation	69,649	32,398	102,047	68%	0.77	0.90	1.13
Colombia	10,714	5,008	15,722	68%	0.81	0.96	1.19
Rest of South African Customs Union	1,639	771	2,410	68%	0.89	1.02	1.31
Lao People's Democratic Republic	571	272	843	68%	0.85	1.17	1.25
Venezuela	11,136	5,325	16,461	68%	0.73	0.86	1.07
China	354,874	169,967	524,842	68%	0.62	0.77	0.92
Finland	36,916	17,738	54,653	68%	0.70	0.82	1.04
Estonia	5,759	2,785	8,544	67%	0.77	0.92	1.15
Rest of Central America	8,041	3,896	11,937	67%	0.81	0.92	1.20
Belgium	174,413	84,594	259,007	67%	0.78	0.89	1.16
Norway	31,390	15,317	46,707	67%	0.74	0.88	1.10
Botswana	2,668	1,304	3,972	67%	0.90	1.04	1.33
Myanmar	2,144	1,078	3,222	67%	0.87	1.08	1.31
Ethiopia	2,270	1,153	3,424	66%	0.79	0.97	1.19
Rest of Western Asia	152,753	79,161	231,914	66%	0.74	0.96	1.13
Nicaragua	1,588	824	2,412	66%	0.77	0.90	1.17
Rest of South America	1,136	602	1,739	65%	0.85	1.03	1.30
Kazakhstan	9,598	5,205	14,803	65%	0.71	0.87	1.10
Madagascar	876	476	1,351	65%	0.82	0.96	1.26

Table A-2

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports (Tau-1, Tau-2, Tau-3)

GTAP Country or Region	Import Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Portugal	36,809	20,085	56,894	65%	0.74	0.88	1.15
Albania	1,794	986	2,780	65%	0.80	0.90	1.23
South Africa	31,472	17,358	48,830	64%	0.72	1.02	1.12
Ecuador	4,928	2,736	7,665	64%	0.84	1.00	1.30
Latvia	5,095	2,885	7,979	64%	0.82	0.95	1.28
Indonesia	38,953	22,115	61,068	64%	0.77	0.91	1.21
Rest of East Asia	4,444	2,584	7,028	63%	0.67	0.87	1.06
Taiwan	102,159	59,449	161,607	63%	0.52	0.68	0.82
Nigeria	11,996	7,092	19,088	63%	0.82	0.97	1.30
Rest of South Asia	3,086	1,828	4,914	63%	0.71	0.91	1.14
Croatia	10,466	6,200	16,666	63%	0.77	0.96	1.23
Rest of Europe	14,418	8,678	23,095	62%	0.79	0.94	1.27
Central Africa	3,760	2,283	6,043	62%	0.70	0.87	1.13
Italy	210,774	129,896	340,671	62%	0.74	1.01	1.20
Iran Islamic Republic of	24,467	15,108	39,575	62%	0.75	1.00	1.21
Uganda	1,070	662	1,732	62%	0.77	0.95	1.25
Brazil	41,485	25,790	67,276	62%	0.62	0.69	1.00
Tanzania	1,882	1,211	3,093	61%	0.77	0.93	1.26
Bulgaria	8,647	5,606	14,254	61%	0.70	0.79	1.16
Thailand	53,743	35,419	89,162	60%	0.51	0.83	0.85
Rest of North Africa	16,804	11,153	27,956	60%	0.64	0.76	1.06
Greece	32,844	21,907	54,752	60%	0.74	0.85	1.23
Morocco	11,113	7,594	18,706	59%	0.65	0.79	1.09
Peru	5,657	3,879	9,536	59%	0.77	0.92	1.30
Zambia	1,044	721	1,765	59%	0.72	0.90	1.22
Rest of Former Soviet Union	4,036	2,793	6,829	59%	0.65	0.82	1.09
Netherlands	97,597	68,055	165,652	59%	0.73	0.86	1.24
Sri Lanka	5,264	3,672	8,936	59%	0.74	0.99	1.26
Rest of Oceania	5,770	4,075	9,845	59%	0.69	0.82	1.18
Rest of Eastern	8,315	5,894	14,209	59%	0.71	0.89	1.21

Table A-2

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports (Tau-1, Tau-2, Tau-3)

GTAP Country or Region	Import Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Africa							
Chile	13,625	9,689	23,314	58%	0.70	0.83	1.20
Turkey	53,567	39,636	93,204	57%	0.69	1.34	1.20
Caribbean	29,075	21,708	50,782	57%	0.68	0.79	1.18
Mauritius	1,744	1,308	3,053	57%	0.65	0.80	1.13
Rest of Western Africa	14,333	10,946	25,279	57%	0.77	0.91	1.35
Zimbabwe	1,190	928	2,117	56%	0.74	0.87	1.32
Japan	241,127	188,346	429,473	56%	0.50	0.61	0.89
Korea	122,322	97,040	219,362	56%	0.47	0.70	0.84
Georgia	1,328	1,062	2,389	56%	0.66	0.77	1.19
Lithuania	7,428	6,057	13,485	55%	0.66	0.77	1.19
Pakistan	11,753	9,773	21,526	55%	0.66	1.03	1.21
Malawi	539	458	996	54%	0.69	0.81	1.27
Azerbaijan	2,799	2,510	5,310	53%	0.57	0.68	1.08
Mozambique	958	920	1,878	51%	0.64	0.78	1.25
Bangladesh	6,429	6,180	12,609	51%	0.63	0.73	1.23
Egypt	9,242	9,136	18,379	50%	0.58	0.77	1.14
Uruguay	2,155	2,155	4,310	50%	0.63	0.79	1.26
Rest of Eastern Europe	1,392	1,404	2,796	50%	0.67	0.77	1.35
Senegal	1,476	1,790	3,266	45%	0.56	0.76	1.24
Armenia	710	869	1,580	45%	0.58	1.36	1.30
South Central Africa	3,859	4,795	8,655	45%	0.52	0.68	1.18
Ukraine	16,246	21,661	37,907	43%	0.52	0.61	1.21
Belarus	7,213	11,055	18,268	39%	0.48	0.58	1.22
Rest of North America	1,354	2,512	3,866	35%	0.26	0.39	0.74
India	36,317	70,216	106,533	34%	0.32	1.74	0.92

Table A-3

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports(Tau-1, Tau-2, Tau-3)

GTAP Sector	Export Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Bangladesh	9,349	901	10,249	91%	0.58	0.61	0.64
Philippines	43,948	5,236	49,185	89%	0.47	0.51	0.53
Taiwan	162,516	21,177	183,694	88%	0.71	0.79	0.80
Malta	3,532	460	3,992	88%	0.38	0.42	0.43
Singapore	103,104	16,186	119,290	86%	0.70	0.85	0.81
Cambodia	3,167	509	3,676	86%	0.59	0.61	0.68
Hungary	44,633	7,897	52,530	85%	0.85	0.90	1.00
Ireland	97,366	17,264	114,630	85%	0.51	0.57	0.60
Korea	227,256	44,278	271,533	84%	0.88	1.02	1.05
Japan	493,496	99,291	592,787	83%	0.92	1.10	1.10
Costa Rica	8,695	1,855	10,549	82%	0.76	0.82	0.92
Germany	697,660	150,346	848,006	82%	0.97	1.08	1.18
China	515,258	114,258	629,516	82%	0.65	0.72	0.79
Sri Lanka	5,284	1,328	6,611	80%	0.66	0.69	0.82
Czech Republic	47,888	13,246	61,134	78%	0.85	0.94	1.09
Rest of Central America	6,508	1,809	8,316	78%	0.72	0.91	0.92
United States of America	643,344	200,368	843,712	76%	0.71	0.87	0.94
Slovenia	12,555	3,995	16,549	76%	0.88	0.97	1.16
Hong Kong	17,927	5,787	23,714	76%	0.61	2.71	0.81
Italy	254,047	82,307	336,354	76%	0.78	0.89	1.03
Malaysia	108,924	35,764	144,688	75%	0.52	0.61	0.70
United Kingdom	228,972	75,660	304,632	75%	0.79	0.93	1.05
France	306,203	103,790	409,993	75%	0.84	0.96	1.13
Portugal	28,522	10,082	38,604	74%	0.78	0.85	1.06
Sweden	88,906	31,844	120,750	74%	0.84	1.01	1.14
Thailand	80,441	30,106	110,548	73%	0.68	0.80	0.94
Austria	70,560	26,416	96,976	73%	0.80	0.97	1.10
Rest of East Asia	4,979	1,930	6,908	72%	0.53	0.87	0.74
Mexico	130,887	52,038	182,925	72%	0.70	0.78	0.98
Finland	44,615	18,010	62,625	71%	0.99	1.14	1.38
Slovakia	20,299	8,208	28,507	71%	1.00	1.12	1.40

Table A-3

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports(Tau-1, Tau-2, Tau-3)

GTAP Sector	Export Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Pakistan	10,857	4,415	15,272	71%	0.50	0.54	0.71
Switzerland	89,756	39,270	129,026	70%	0.65	1.80	0.93
Tunisia	7,503	3,352	10,856	69%	0.54	0.61	0.78
Turkey	47,034	21,405	68,438	69%	0.74	0.86	1.08
Spain	123,584	57,180	180,763	68%	0.95	1.07	1.39
Belgium	159,962	74,776	234,738	68%	0.95	1.18	1.40
Poland	45,913	22,684	68,597	67%	0.75	0.84	1.12
Romania	16,591	8,629	25,220	66%	0.63	0.71	0.95
Luxembourg	8,394	4,429	12,823	65%	0.74	1.52	1.13
Albania	486	273	760	64%	0.57	0.73	0.89
Panama	780	447	1,227	64%	1.46	1.57	2.30
Netherlands	108,867	63,728	172,594	63%	0.89	1.07	1.41
Greece	12,228	7,539	19,767	62%	0.71	0.86	1.15
Caribbean	19,591	12,140	31,731	62%	0.70	0.80	1.13
Denmark	42,887	27,551	70,438	61%	0.57	0.64	0.94
Croatia	5,579	3,601	9,179	61%	0.64	0.80	1.05
Belarus	8,306	5,506	13,812	60%	0.91	1.02	1.52
Morocco	7,894	5,425	13,319	59%	0.43	0.54	0.72
Lithuania	5,552	3,936	9,488	59%	0.78	0.85	1.33
Nicaragua	927	665	1,592	58%	0.44	0.91	0.76
Guatemala	2,714	2,087	4,801	57%	0.88	0.99	1.56
Bulgaria	6,093	4,701	10,794	56%	0.57	0.67	1.01
India	50,755	39,424	90,179	56%	0.56	0.65	0.99
Estonia	3,612	2,833	6,445	56%	0.52	0.73	0.94
Canada	163,985	128,638	292,623	56%	0.74	0.98	1.32
Mauritius	1,589	1,267	2,856	56%	0.42	0.84	0.76
Rest of North America	392	324	717	55%	0.33	0.35	0.60
Rest of South America	1,031	970	2,002	52%	0.75	3.50	1.46
Rest of Europe	5,317	5,282	10,599	50%	0.58	0.75	1.15
Cyprus	872	871	1,742	50%	0.49	0.63	0.97
Viet Nam	14,148	14,373	28,521	50%	0.33	0.38	0.66

Table A-3

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports(Tau-1, Tau-2, Tau-3)

GTAP Sector	Export Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Lao People's Democratic Republic	209	215	424	49%	0.37	0.56	0.74
Egypt	5,684	6,021	11,705	49%	0.65	0.82	1.34
Madagascar	843	915	1,758	48%	0.31	0.66	0.64
Indonesia	42,028	45,953	87,981	48%	0.50	0.68	1.04
Rest of South Asia	786	963	1,749	45%	0.44	0.54	0.98
Latvia	1,811	2,565	4,376	41%	0.40	0.60	0.97
Ecuador	3,955	6,054	10,010	40%	0.84	0.88	2.13
Myanmar	857	1,321	2,178	39%	0.24	0.31	0.62
Colombia	7,152	11,244	18,397	39%	0.63	1.15	1.61
Brazil	43,140	69,494	112,634	38%	0.47	0.77	1.24
South Africa	20,823	35,989	56,812	37%	0.50	1.50	1.35
Rest of South African Customs Union	1,468	2,566	4,033	36%	0.29	0.54	0.80
Uruguay	1,311	2,416	3,727	35%	0.38	0.55	1.07
Rest of Eastern Europe	495	919	1,414	35%	0.31	0.37	0.88
Senegal	453	865	1,318	34%	0.41	0.70	1.20
Ukraine	11,065	22,719	33,784	33%	0.43	0.59	1.32
Rest of EFTA	1,404	3,202	4,605	30%	0.26	0.34	0.86
Rest of Eastern Africa	2,812	6,484	9,295	30%	0.32	0.61	1.06
New Zealand	6,813	15,865	22,679	30%	0.34	0.59	1.12
Argentina	10,815	27,625	38,440	28%	0.40	0.53	1.43
Zambia	566	1,500	2,066	27%	0.37	0.64	1.34
Armenia	210	570	780	27%	0.20	1.17	0.74
Australia	23,030	67,544	90,574	25%	0.33	1.22	1.30
Rest of Western Asia	79,164	245,443	324,607	24%	0.34	0.51	1.38
Venezuela	9,012	27,942	36,955	24%	0.45	0.52	1.83
Tanzania	403	1,316	1,719	23%	0.22	1.37	0.94
Peru	2,856	9,759	12,615	23%	0.29	2.01	1.26
Georgia	236	818	1,054	22%	0.20	0.41	0.91

Table A-3

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports(Tau-1, Tau-2, Tau-3)

GTAP Sector	Export Value with Significant Hummels' HS4 Estimate (Millions of US\$)				Ad valorem Value of One Day*		
	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Azerbaijan	837	2,912	3,749	22%	0.43	0.44	1.91
Rest of Oceania	1,396	5,517	6,913	20%	0.18	1.99	0.90
Russian Federation	38,709	159,590	198,299	20%	0.30	0.41	1.54
Ethiopia	189	811	1,000	19%	0.17	0.53	0.91
Norway	13,923	62,476	76,399	18%	0.21	0.27	1.16
Kyrgyzstan	182	850	1,033	18%	0.20	4.56	1.13
Chile	5,980	28,842	34,822	17%	0.27	0.46	1.59
Malawi	124	610	735	17%	0.16	0.18	0.95
Rest of Western Africa	2,996	15,700	18,696	16%	0.24	0.87	1.49
Rest of Southeast Asia	641	3,806	4,447	14%	0.10	0.11	0.71
Rest of Former Soviet Union	1,547	9,944	11,492	13%	0.24	0.43	1.75
Zimbabwe	279	1,996	2,275	12%	0.15	0.96	1.21
Bolivia	267	1,972	2,239	12%	0.09	0.37	0.79
Central Africa	1,195	11,566	12,762	9%	0.16	0.24	1.69
Iran Islamic Republic of	4,186	41,779	45,965	9%	0.13	0.16	1.39
Rest of North Africa	3,873	42,212	46,085	8%	0.16	0.16	1.86
Botswana	329	3,591	3,920	8%	0.12	0.15	1.45
Uganda	131	1,501	1,632	8%	0.10	0.74	1.27
Mozambique	131	1,809	1,940	7%	0.04	0.07	0.56
Kazakhstan	1,451	20,805	22,256	7%	0.11	0.36	1.63
Paraguay	230	3,891	4,122	6%	0.05	0.29	0.84
Nigeria	575	34,755	35,331	2%	0.02	0.02	0.98
South Central Africa	142	13,461	13,602	1%	0.01	0.03	1.27

