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

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ILLUSTRATIONS

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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 trade[1]. 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 Database[2] on time delays for crossing international borders and find that reported time delays in the movement of international cargo are frequently more significant then 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 delivery[3].

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.

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[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 81 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 134 countries and regions and 57 sector in version 81 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 134 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.ComPairdata.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 exception[5]. 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 2007 database of trade values[6]. 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).

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

[6] MacMap 2007 provides the HS6 basis of trade and protection data implemented in the GTAP 81 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

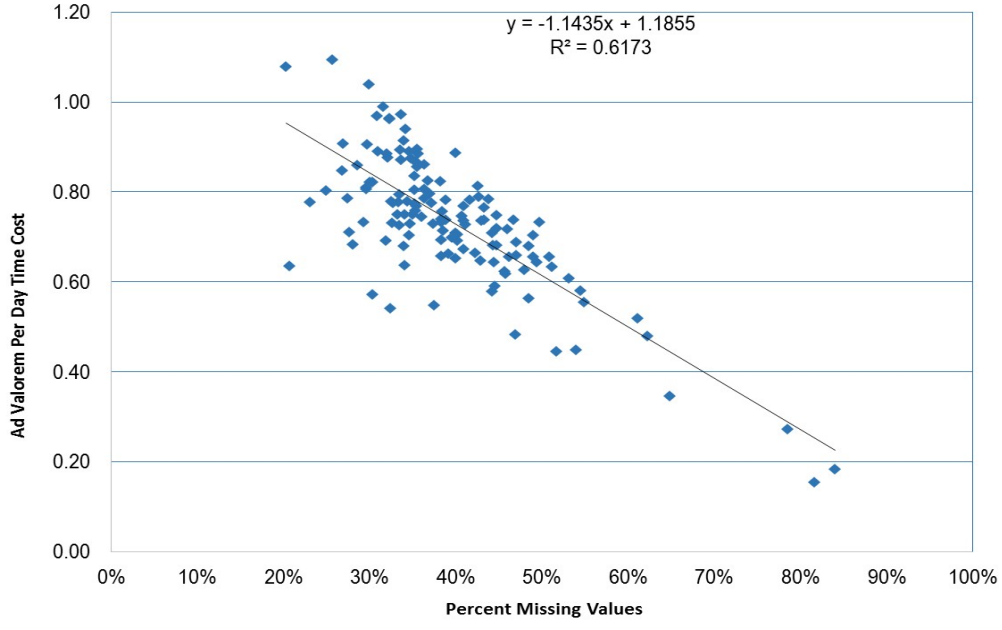
Table 1
MacMap 2007 HS4 Data Base and Correspondence with Hummels' HS4 Time Cost Estimates

	Number of Obs.	Value (Millions of Dollars)	Percent	
			Number of Obs.	Value
No Time Cost Estimate	12,610,434	5,740,163	53%	38%
Time Cost Estimate	11,047,872	9,469,600	47%	62%
Total	23,658,306	15,209,762	100%	100%

Source: Author's calculations from MacMap 2007 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.

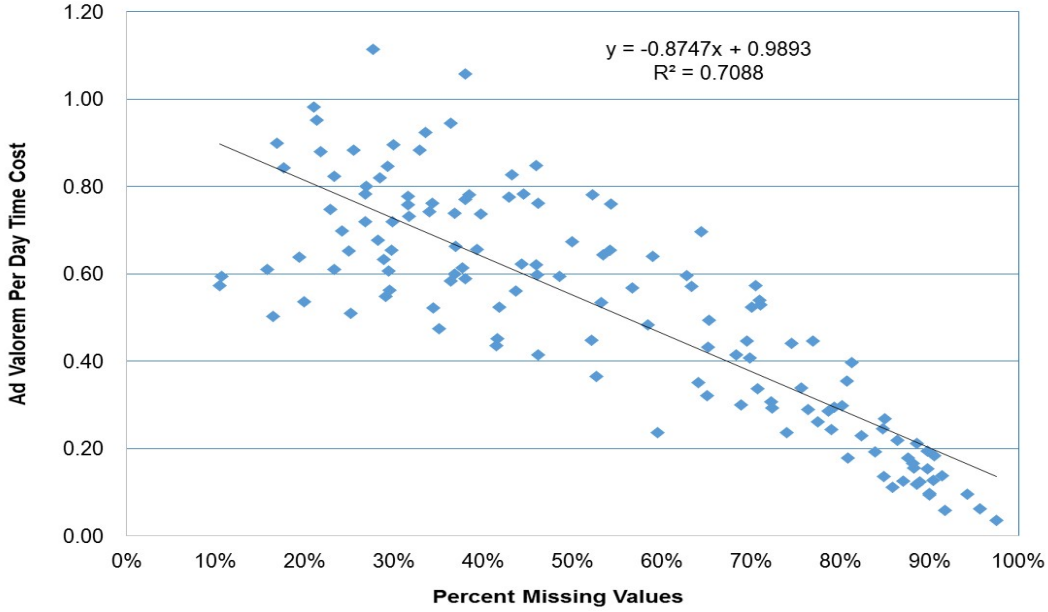
Figure 1
Import Weighted Average Value of the Ad Volrem *Per Day Time Cost, by GTAP Region and Percent of Missing Values 2007 (Tau-1)**



Source: MacMap 2007 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 Volrem *Per Day Time Cost, by GTAP Region and Percent of Missing Values 2007 (Tau-1)**



Source: MacMap 2007 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 prioi* 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 0.68 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 1.1 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 2007 (Tau-2)*

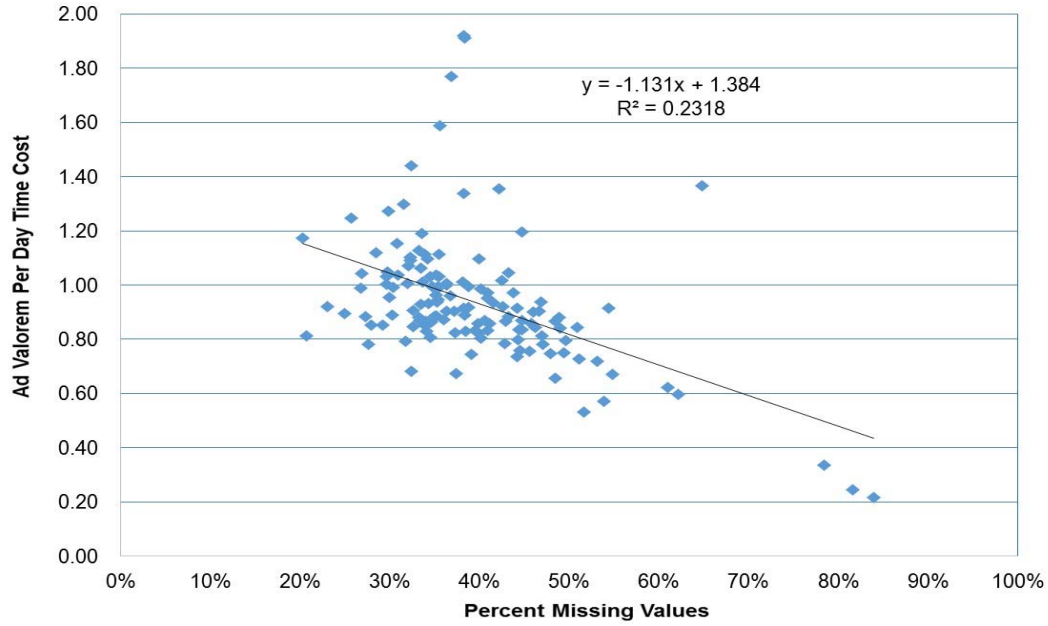


Figure 4

Export Weighted Average Value of the Ad-Volrem *Time Per Day Time Cost, by GTAP Region and Percent of Missing Values 2007 (Tau-2)*

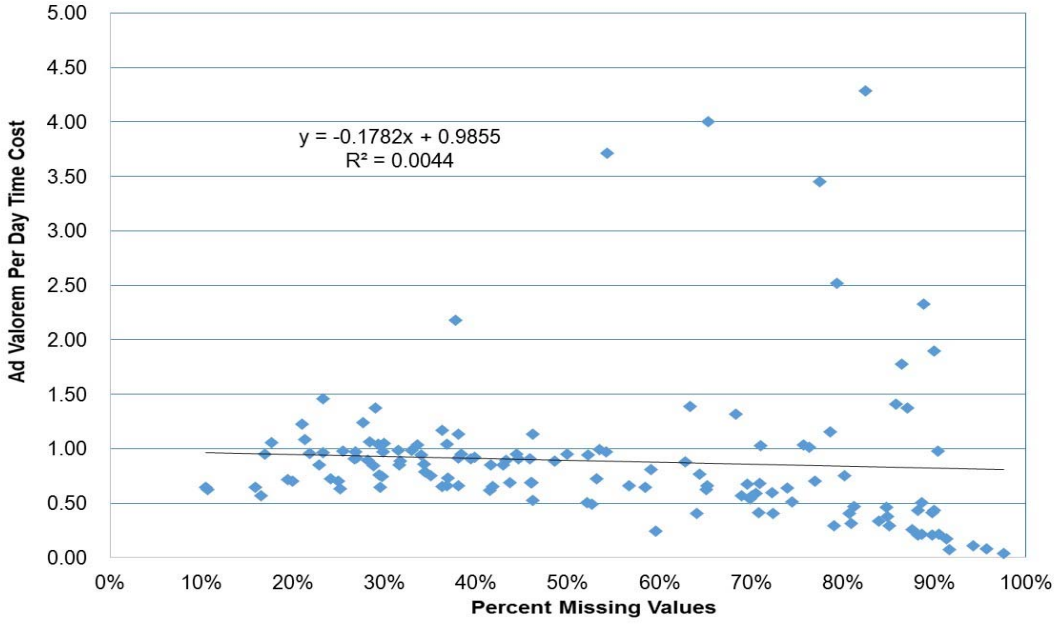


Figure 5

Import Weighted Average Value of the Ad Volrem *Per Day Time Cost, by GTAP Region and Percent of Missing Values 2007 (Tau-3)*

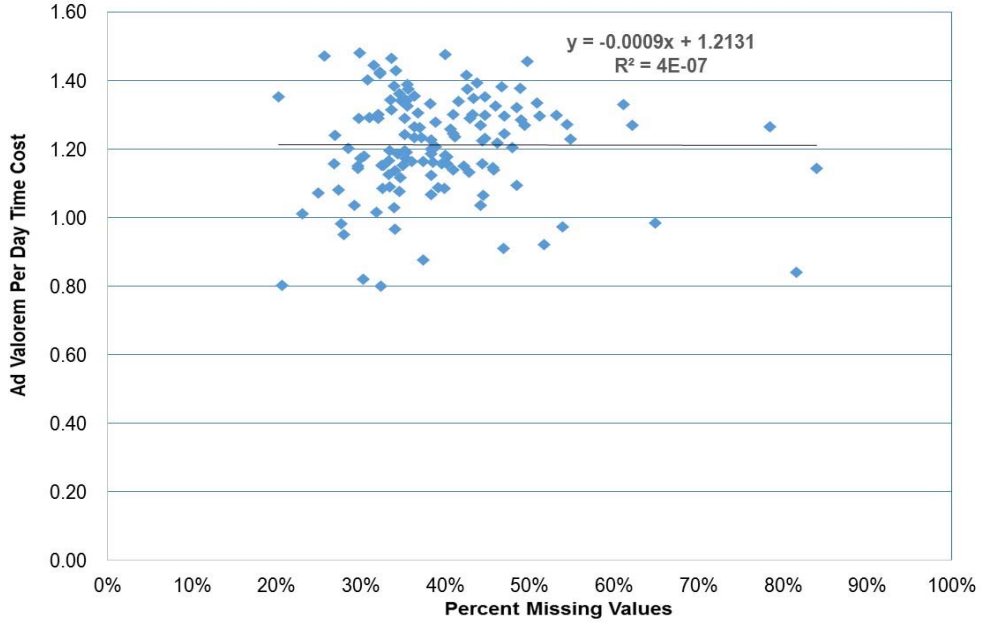
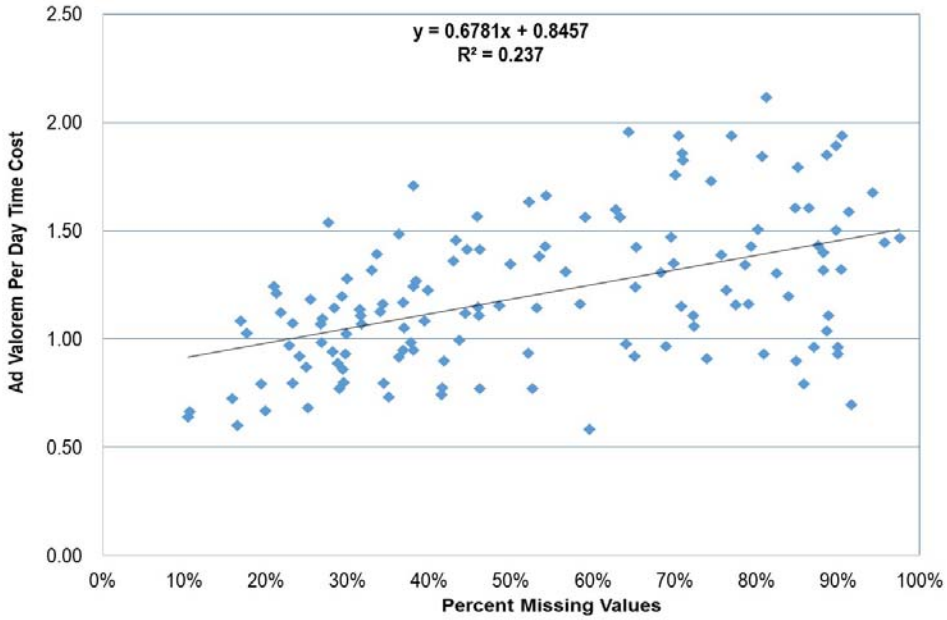


Figure 6

Export Weighted Average Value of the Ad Volrem *Per Day Time Cost, by GTAP Region and Percent of Missing Values 2007 (Tau-3)*



Two Tier Trade Weighting for a GTAP Database

In the prior analysis, HS4 time costs are trade weighted employing the MacMap 2007 database. MacMap 2007 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 81 database. Therefore, creation of the trade weighted values of time for the GTAP 81 database requires a two-step procedure: first HS4 time estimates are aggregated to the GTAP commodity and country level utilizing the MacMap 2007 database and second, further aggregation, above the 57 GTAP sectors, must be carried out with GTAP 81 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 manner[7]. 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.

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[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:

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:

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

$\sigma_m^i =$ 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

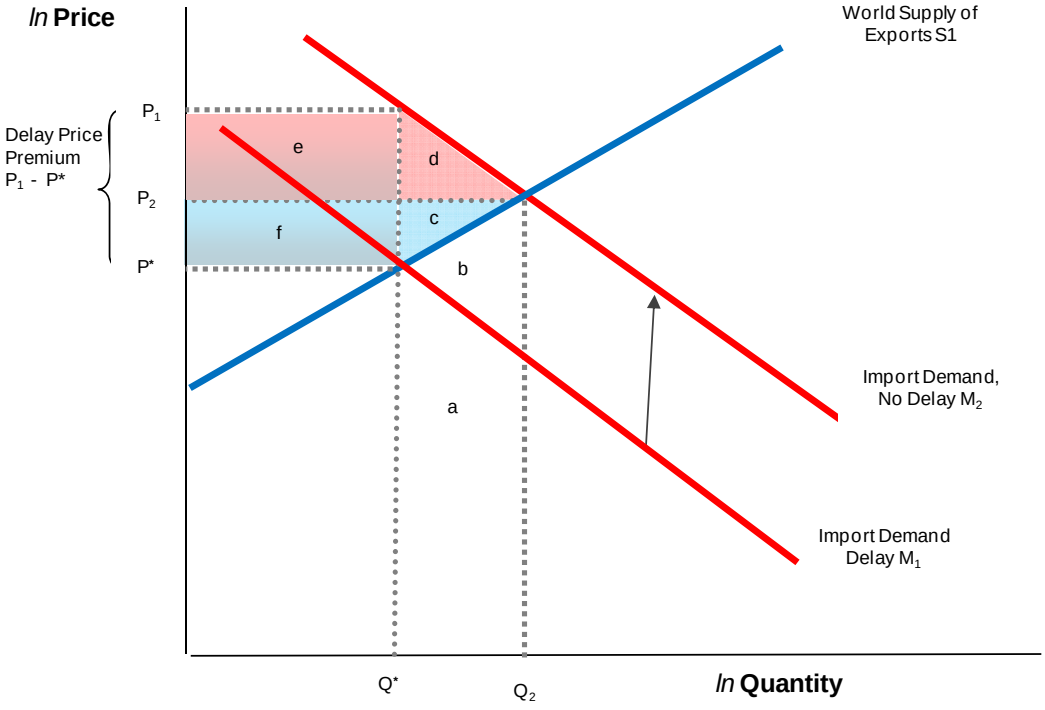
Figure 7 provides a partial equilibrium representation of a reduction in shipping time on import demand and the supply price of exports. For exposition purposes, no tariffs or quotas are included. S_1 is the world supply of the commodity and M_1 is the initial import demand curve. P^* is the initial 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 series[9]. 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 2007, the same year as the GTAP v81 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 2007[10]. Missing data were estimated utilizing regional averages for those countries reporting.

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http://www.doingbusiness.org/[9]

[10] Countries without 2007 data include: Cyprus (estimated with 2008 data), Malta (estimated with 2012 data), Qatar (estimated with 2008 data), Bahrain (estimated with 2008 data), Rest of North America, Rest of South East Asia, and Rest of the World.

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 directory[11]. 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 considered 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 vales 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 prioi* 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 0.68 percent for tau-1, 0.89 percent for tau-2, and 1.1 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.

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Appendix A

Table A-1
Missing Values and Per Day Ad Valorem Time Cost Estimates by GTAP Commodity 2007 (Tau-1, Tau-2, Tau-3)

	Trade Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Sector	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	262	--	262	100%	1.47	1.47	1.47
Electronic equipment	1,422,914	10,123	1,433,038	99%	0.58	0.58	0.58
Wearing apparel	260,092	5,402	265,494	98%	0.71	0.71	0.73
Motor vehicles and parts	1,300,792	211,963	1,512,755	86%	1.52	1.56	1.77
Petroleum, coal products	574,073	95,658	669,731	86%	1.71	1.71	1.99
Machinery and equipment nec	2,128,759	378,553	2,507,312	85%	0.58	0.77	0.68
Metal products	277,462	53,679	331,141	84%	0.79	0.87	0.94
Textiles	286,844	71,428	358,272	80%	0.58	0.66	0.73
Chemical, rubber, plastic products	1,531,743	414,966	1,946,709	79%	1.06	1.19	1.34
Manufactures nec	293,815	118,220	412,035	71%	0.64	0.65	0.89
Paper products, publishing	188,865	83,475	272,340	69%	1.37	1.39	1.98
Leather products	109,522	67,000	176,522	62%	0.30	0.30	0.48
Transport equipment nec	399,799	255,958	655,757	61%	0.44	0.48	0.72
Mineral products nec	96,542	68,114	164,656	59%	0.97	1.03	1.65
Food products nec	170,546	126,513	297,059	57%	0.94	1.21	1.63
Beverages and tobacco products	42,597	67,439	110,036	39%	0.22	0.38	0.57
Wood products	117,054	191,345	308,399	38%	0.14	0.26	0.38
Fishing	5,831	12,408	18,239	32%	0.18	0.18	0.57
Metals nec	134,088	430,330	564,418	24%	0.38	3.42	1.59
Wool, silk-worm cocoons	964	3,120	4,084	24%	0.19	0.49	0.81
Vegetables, fruit, nuts	21,783	90,218	112,000	19%	0.57	0.94	2.93
Ferrous metals	83,080	495,613	578,693	14%	0.28	0.69	1.96
Animal products nec	3,168	20,319	23,487	13%	0.15	2.24	1.13
Vegetable oils and fats	7,986	82,888	90,874	9%	0.14	0.16	1.55
Meat products nec	4,680	55,812	60,492	8%	0.13	0.13	1.65
Crops nec	4,481	60,773	65,255	7%	0.10	0.11	1.47
Forestry	920	19,595	20,516	4%	0.05	0.05	1.00

Table A-1
Missing Values and Per Day Ad Valorem Time Cost Estimates by GTAP Commodity 2007 (Tau-1, Tau-2, Tau-3)

	Trade Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Sector	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Bovine cattle, sheep and goats, horses	324	10,545	10,869	3%	0.01	0.01	0.39
Minerals nec	614	240,441	241,055	0%	0.00	0.16	0.90
Oil seeds	--	45,271	45,271	--	0.00	0.57	--
Cereal grains nec	--	35,189	35,189	--	0.00	0.00	--
Gas manufacture, distribution	--	33	33	--	0.00	0.00	--
Coal	--	91,119	91,119	--	0.00	0.00	--
Gas	--	218,940	218,940	--	0.00	0.00	--
Oil	--	1,373,040	1,373,040	--	0.00	0.00	--
Wheat	--	42,575	42,575	--	0.00	0.00	--
Dairy products	--	62,932	62,932	--	0.00	0.04	--
Sugar	--	23,454	23,454	--	0.00	0.02	--
Plant-based fibers	--	12,733	12,733	--	0.00	0.00	--
Bovine meat products	--	39,310	39,310	--	0.00	0.09	--
Electricity	--	37,257	37,257	--	0.00	0.00	--
Paddy rice	--	2,383	2,383	--	0.00	0.05	--
Processed rice	--	14,026	14,026	--	0.00	0.05	--
Total	9,469,600	5,740,163	15,209,762	62%	0.68	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 2007 (Tau-1, Tau-2, Tau-3)

	Import Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Country or Region	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Paraguay	5,621	1,430	7,050	80%	1.08	1.17	1.35
Hong Kong	286,159	74,615	360,774	79%	0.64	0.81	0.80
Mexico	226,982	68,178	295,160	77%	0.78	0.92	1.01
Rest of East Asia	4,569	1,520	6,089	75%	0.80	0.89	1.07
Togo	2,602	899	3,502	74%	1.09	1.25	1.47
Costa Rica	11,610	4,248	15,858	73%	0.85	0.99	1.16
Argentina	36,384	13,407	49,791	73%	0.91	1.04	1.24
Ireland	65,143	24,531	89,674	73%	0.79	0.88	1.08
Hungary	68,761	26,243	95,005	72%	0.71	0.78	0.98
Singapore	192,813	74,940	267,753	72%	0.68	0.85	0.95
Kyrgyzstan	3,104	1,238	4,343	71%	0.86	1.12	1.20
Czech Republic	87,648	36,212	123,861	71%	0.73	0.85	1.04
Austria	118,389	49,796	168,185	70%	0.81	1.00	1.15
Canada	294,109	123,802	417,912	70%	0.81	1.03	1.15
Slovenia	23,784	10,058	33,842	70%	0.91	1.05	1.29
Lao People's Democratic Republic	1,578	671	2,249	70%	1.04	1.27	1.48
Burkina Faso	1,202	515	1,717	70%	0.82	0.95	1.17
Malaysia	108,249	47,083	155,332	70%	0.57	0.89	0.82
Cambodia	4,553	1,984	6,536	70%	0.82	0.99	1.18
Estonia	12,785	5,698	18,483	69%	0.97	1.15	1.40
Russian Federation	158,430	71,046	229,476	69%	0.89	1.04	1.29
Bolivia	3,248	1,499	4,747	68%	0.99	1.30	1.45
Slovakia	41,364	19,298	60,662	68%	0.69	0.79	1.02
New Zealand	24,847	11,698	36,545	68%	0.89	1.01	1.30
Rest of Southeast Asia	5,876	2,771	8,647	68%	0.88	1.07	1.29
Guatemala	10,248	4,886	15,134	68%	0.96	1.10	1.42
Tanzania	5,661	2,702	8,363	68%	0.96	1.09	1.42
Philippines	42,128	20,163	62,291	68%	0.54	0.68	0.80
Australia	120,612	57,928	178,539	68%	0.78	1.44	1.15
Germany	710,623	343,325	1,053,948	67%	0.73	0.85	1.08

Table A-2
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports 2007 (Tau-1, Tau-2, Tau-3)

	Import Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Country or Region	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Denmark	76,477	37,101	113,578	67%	0.78	0.91	1.15
United Kingdom	458,288	228,299	686,587	67%	0.75	1.13	1.13
France	449,327	223,958	673,285	67%	0.78	0.88	1.17
Rest of EFTA	8,258	4,141	12,399	67%	0.73	0.87	1.09
Poland	115,756	58,151	173,907	67%	0.80	0.93	1.19
Uganda	2,937	1,480	4,416	66%	0.89	1.06	1.34
Mongolia	1,972	998	2,970	66%	0.97	1.19	1.47
Rest of Oceania	6,540	3,319	9,859	66%	0.87	1.01	1.31
Oman	15,036	7,709	22,745	66%	0.91	1.11	1.38
Rest of Eastern Africa	16,323	8,401	24,724	66%	0.68	0.85	1.03
Sweden	107,975	55,735	163,710	66%	0.75	0.87	1.14
Qatar	21,377	11,048	32,424	66%	0.64	0.83	0.97
Latvia	11,444	5,939	17,384	66%	0.94	1.10	1.43
Colombia	24,719	12,926	37,646	66%	0.78	0.93	1.19
Luxembourg	17,625	9,303	26,928	65%	0.89	1.03	1.36
United States of America	1,402,796	740,832	2,143,628	65%	0.70	0.81	1.08
Venezuela	29,090	15,429	44,520	65%	0.73	0.86	1.12
Honduras	5,961	3,175	9,137	65%	0.88	0.99	1.34
Rest of South African Customs	1,233	663	1,896	65%	0.75	0.88	1.15
Spain	272,661	148,085	420,746	65%	0.77	0.89	1.20
Madagascar	2,399	1,303	3,702	65%	0.81	0.96	1.24
Guinea	1,674	910	2,584	65%	0.84	1.04	1.29
Rwanda	932	508	1,440	65%	0.76	0.94	1.17
Rest of Eastern Europe	3,213	1,753	4,966	65%	0.87	0.99	1.34
Georgia	4,455	2,441	6,895	65%	0.87	0.99	1.34
Benin	3,295	1,808	5,103	65%	0.77	0.95	1.19
Rest of South America	2,141	1,177	3,318	65%	0.90	1.11	1.39
Botswana	3,193	1,756	4,949	65%	0.86	1.03	1.33
Nepal	1,502	831	2,333	64%	0.88	1.59	1.37

Table A-2
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports 2007 (Tau-1, Tau-2, Tau-3)

	Import Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Country or Region	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Romania	48,189	27,105	75,294	64%	0.75	0.87	1.16
Belgium	298,936	170,255	469,191	64%	0.79	0.90	1.23
Kuwait	19,142	10,907	30,050	64%	0.81	1.00	1.27
Rest of South Asia	5,369	3,067	8,436	64%	0.86	1.01	1.35
Rest of Europe	23,440	13,635	37,075	63%	0.83	0.96	1.31
Armenia	1,897	1,110	3,007	63%	0.80	1.77	1.26
Mauritius	3,657	2,165	5,822	63%	0.78	0.90	1.23
El Salvador	6,359	3,787	10,147	63%	0.73	0.83	1.16
China	582,041	347,938	929,979	63%	0.55	0.67	0.88
Namibia	3,295	2,036	5,332	62%	0.82	1.01	1.33
Kazakhstan	23,662	14,681	38,343	62%	0.74	0.91	1.20
Viet Nam	40,322	25,023	65,345	62%	0.73	1.34	1.19
Switzerland	129,879	80,626	210,505	62%	0.66	1.92	1.07
United Arab Emirates	90,941	56,522	147,463	62%	0.69	1.91	1.12
Nicaragua	2,926	1,819	4,744	62%	0.76	0.89	1.23
Tunisia	14,708	9,205	23,913	62%	0.71	0.83	1.16
Kenya	7,655	4,857	12,513	61%	0.78	0.92	1.28
Saudi Arabia	70,254	44,592	114,846	61%	0.74	1.00	1.21
Brazil	85,911	55,192	141,103	61%	0.66	0.74	1.09
Norway	57,566	37,688	95,254	60%	0.70	0.83	1.16
Rest of Former Soviet Union	8,443	5,604	14,047	60%	0.65	0.86	1.09
Rest of Western Asia	42,522	28,308	70,830	60%	0.89	1.10	1.48
Portugal	52,535	34,986	87,521	60%	0.71	0.82	1.18
Finland	53,452	35,901	89,353	60%	0.69	0.80	1.16
Croatia	18,224	12,463	30,686	59%	0.75	0.87	1.26
Nigeria	27,878	19,299	47,177	59%	0.77	0.97	1.30
Netherlands	257,381	178,214	435,595	59%	0.67	0.83	1.14
Italy	314,906	218,076	532,982	59%	0.74	0.95	1.25
Albania	3,063	2,140	5,203	59%	0.73	0.86	1.24
Ecuador	10,238	7,290	17,528	58%	0.78	0.93	1.34

Table A-2
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports 2007 (Tau-1, Tau-2, Tau-3)

	Import Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Country or Region	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
South Africa	53,365	38,950	92,314	58%	0.67	1.36	1.15
Zimbabwe	2,111	1,562	3,673	57%	0.81	1.02	1.42
Rest of Central America	742	550	1,292	57%	0.79	0.92	1.38
Rest of North Africa	30,239	22,675	52,914	57%	0.65	0.78	1.13
Indonesia	57,295	43,047	100,342	57%	0.74	0.87	1.29
Peru	18,360	13,991	32,352	57%	0.74	0.88	1.30
Ethiopia	5,260	4,015	9,275	57%	0.77	1.05	1.35
Ukraine	41,522	32,271	73,792	56%	0.78	0.97	1.39
Azerbaijan	5,773	4,573	10,345	56%	0.58	0.74	1.04
Rest of Western Africa	6,491	5,143	11,634	56%	0.71	0.91	1.27
Greece	50,839	40,481	91,321	56%	0.68	0.80	1.22
Zambia	3,082	2,462	5,544	56%	0.64	0.83	1.16
Central Africa	6,091	4,885	10,977	55%	0.59	0.76	1.07
Chile	29,986	24,217	54,204	55%	0.72	0.83	1.30
Turkey	99,174	80,141	179,316	55%	0.68	1.20	1.23
Lithuania	16,177	13,085	29,262	55%	0.75	0.87	1.35
Israel	32,621	27,353	59,974	54%	0.62	0.76	1.15
South Central Africa	11,935	10,064	21,999	54%	0.62	0.86	1.14
Sri Lanka	7,813	6,645	14,458	54%	0.72	0.90	1.33
Iran Islamic Republic of	27,687	23,757	51,444	54%	0.66	0.84	1.22
Malawi	1,236	1,079	2,315	53%	0.74	0.90	1.38
Thailand	82,215	72,551	154,766	53%	0.48	0.94	0.91
Uruguay	4,801	4,248	9,049	53%	0.69	0.81	1.30
Bulgaria	18,263	16,209	34,472	53%	0.66	0.78	1.25
Morocco	20,626	19,005	39,632	52%	0.63	0.75	1.20
Pakistan	21,970	20,647	42,618	52%	0.68	0.87	1.32
Malta	5,846	5,497	11,343	52%	0.56	0.66	1.09
Senegal	3,545	3,392	6,937	51%	0.70	0.88	1.38
Mozambique	2,433	2,333	4,766	51%	0.66	0.84	1.29

Table A-2
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Imports 2007 (Tau-1, Tau-2, Tau-3)

	Import Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Country or Region	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Caribbean	40,236	39,242	79,478	51%	0.64	0.75	1.27
Cyprus	10,608	10,464	21,071	50%	0.73	0.80	1.46
Ghana	5,247	5,429	10,676	49%	0.66	0.84	1.34
Bangladesh	10,441	10,936	21,377	49%	0.63	0.73	1.30
Japan	325,648	348,424	674,072	48%	0.45	0.53	0.92
Belarus	15,009	17,012	32,021	47%	0.61	0.72	1.30
Korea	177,388	207,191	384,579	46%	0.45	0.57	0.97
Egypt	21,585	25,763	47,348	46%	0.58	0.91	1.27
Cameroon	2,084	2,534	4,618	45%	0.56	0.67	1.23
Bahrain	5,620	8,805	14,425	39%	0.52	0.62	1.33
Cote d'Ivoire	3,163	5,200	8,362	38%	0.48	0.60	1.27
India	92,036	169,555	261,590	35%	0.35	1.37	0.98
Panama	7,779	28,273	36,052	22%	0.27	0.34	1.26
Rest of North America	1,716	7,594	9,310	18%	0.16	0.25	0.84
Taiwan	31,063	162,861	193,924	16%	0.18	0.22	1.14

Table A-3
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports 2007(Tau-1, Tau-2, Tau-3)

	Export Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Sector	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Taiwan	113,557	13,293	126,850	90%	0.57	0.64	0.64
Bangladesh	14,959	1,783	16,742	89%	0.59	0.63	0.67
Ireland	141,188	27,831	169,019	84%	0.50	0.57	0.60
Hungary	75,148	15,259	90,407	83%	0.90	0.95	1.08
Singapore	172,059	36,966	209,025	82%	0.84	1.05	1.02
China	1,262,417	303,799	1,566,216	81%	0.64	0.72	0.79
Philippines	50,175	12,514	62,689	80%	0.54	0.70	0.67
Japan	663,343	176,294	839,638	79%	0.98	1.23	1.24
Germany	1,063,929	287,869	1,351,798	79%	0.95	1.09	1.21
Czech Republic	92,120	25,632	117,752	78%	0.88	0.96	1.12
Costa Rica	12,801	3,786	16,587	77%	0.75	0.85	0.97
Hong Kong	58,926	17,863	76,789	77%	0.61	1.46	0.79
Korea	342,733	104,063	446,796	77%	0.82	0.97	1.07
Malta	6,125	1,948	8,072	76%	0.70	0.73	0.92
Sri Lanka	7,098	2,363	9,462	75%	0.65	0.71	0.87
Cambodia	5,212	1,750	6,962	75%	0.51	0.63	0.68
Slovenia	21,043	7,186	28,229	75%	0.88	0.98	1.18
Italy	370,639	135,254	505,893	73%	0.78	0.91	1.07
United States of America	937,709	343,357	1,281,066	73%	0.72	0.97	0.98
France	452,491	166,234	618,724	73%	0.80	0.92	1.10
Slovakia	42,386	16,207	58,593	72%	1.11	1.24	1.54
Rest of East Asia	4,365	1,715	6,080	72%	0.68	0.89	0.94
United Kingdom	336,428	133,438	469,867	72%	0.82	1.07	1.14
Honduras	4,613	1,868	6,481	71%	0.63	0.84	0.89
Mauritius	2,056	841	2,897	71%	0.55	1.38	0.77
Sweden	131,037	54,409	185,445	71%	0.85	1.04	1.20
Rest of South African Customs	2,475	1,032	3,507	71%	0.61	0.76	0.86
Malaysia	153,571	64,261	217,833	70%	0.56	0.64	0.80
El Salvador	3,228	1,362	4,590	70%	0.65	0.75	0.93
Thailand	128,154	54,355	182,509	70%	0.72	0.97	1.02
Finland	71,862	30,705	102,567	70%	0.90	1.05	1.28

Table A-3
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports 2007(Tau-1, Tau-2, Tau-3)

	Export Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Sector	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Austria	113,993	52,506	166,499	68%	0.78	0.98	1.14
Portugal	38,716	17,859	56,575	68%	0.76	0.85	1.11
Mexico	203,265	94,373	297,638	68%	0.73	0.88	1.07
Rest of the World	49	24	74	67%	0.88	0.99	1.32
Spain	187,323	94,612	281,935	66%	0.92	1.03	1.39
Luxembourg	17,702	9,117	26,820	66%	0.74	0.94	1.13
Poland	94,135	49,165	143,300	66%	0.76	0.86	1.16
Pakistan	14,960	7,858	22,819	66%	0.52	0.79	0.80
Madagascar	1,108	598	1,706	65%	0.47	0.76	0.73
Tunisia	12,429	7,086	19,514	64%	0.58	0.65	0.92
Belgium	222,618	126,921	349,539	64%	0.94	1.17	1.48
Cyprus	4,734	2,750	7,484	63%	0.60	0.66	0.95
Turkey	80,922	47,156	128,078	63%	0.74	1.04	1.17
Romania	30,240	17,690	47,929	63%	0.66	0.73	1.05
Switzerland	138,328	83,644	221,972	62%	0.61	2.18	0.98
Denmark	67,741	41,546	109,287	62%	0.59	0.66	0.95
Belarus	16,058	9,853	25,912	62%	1.06	1.13	1.71
Estonia	8,847	5,432	14,279	62%	0.77	0.92	1.24
Netherlands	267,789	166,823	434,612	62%	0.78	0.95	1.27
Nepal	564	366	931	61%	0.66	0.91	1.08
Greece	17,492	11,551	29,042	60%	0.74	0.92	1.22
Togo	1,155	817	1,972	59%	0.44	0.62	0.74
Nicaragua	1,750	1,247	2,996	58%	0.45	0.85	0.77
Israel	38,211	27,434	65,644	58%	0.52	0.65	0.90
Caribbean	36,497	27,417	63,914	57%	0.78	0.85	1.36
Lithuania	11,292	8,611	19,903	57%	0.83	0.89	1.46
Albania	1,338	1,038	2,376	56%	0.56	0.69	0.99
India	108,573	86,557	195,130	56%	0.62	0.95	1.12
Latvia	6,266	5,039	11,305	55%	0.78	0.90	1.41
Bahrain	5,602	4,750	10,352	54%	0.85	0.91	1.57
Bulgaria	12,647	10,758	23,405	54%	0.62	0.69	1.15
Croatia	8,678	7,415	16,092	54%	0.60	0.69	1.11

Table A-3
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports 2007(Tau-1, Tau-2, Tau-3)

	Export Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Sector	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Guatemala	4,594	3,933	8,526	54%	0.76	1.14	1.41
Morocco	12,030	10,331	22,361	54%	0.41	0.53	0.77
Kenya	2,914	2,747	5,661	51%	0.59	0.89	1.15
Canada	225,770	225,061	450,830	50%	0.67	0.95	1.35
Rest of EFTA	3,995	4,345	8,340	48%	0.45	0.51	0.93
Benin	438	479	918	48%	0.78	0.94	1.63
Viet Nam	30,075	33,459	63,534	47%	0.36	0.49	0.77
Rest of Europe	10,025	11,389	21,413	47%	0.53	0.73	1.14
Rest of Central America	1,312	1,504	2,816	47%	0.64	0.99	1.38
Senegal	986	1,167	2,152	46%	0.65	0.97	1.43
Rest of South America	1,323	1,571	2,893	46%	0.76	3.72	1.66
Panama	3,777	4,951	8,727	43%	0.57	0.66	1.31
Indonesia	66,769	93,963	160,732	42%	0.48	0.64	1.16
Egypt	15,079	21,727	36,806	41%	0.64	0.81	1.56
Rest of North America	790	1,165	1,956	40%	0.24	0.24	0.58
Colombia	14,166	23,901	38,067	37%	0.60	0.88	1.60
Georgia	1,174	2,029	3,203	37%	0.57	1.39	1.56
Rest of Eastern Europe	902	1,610	2,512	36%	0.35	0.41	0.98
Ecuador	6,882	12,445	19,327	36%	0.70	0.77	1.96
Armenia	541	1,008	1,549	35%	0.32	0.62	0.92
Brazil	73,795	138,323	212,118	35%	0.43	0.66	1.24
Kyrgyztan	503	948	1,451	35%	0.49	4.00	1.42
South Africa	33,682	72,826	106,509	32%	0.41	1.32	1.31
Uruguay	2,223	4,934	7,157	31%	0.30	0.57	0.97
Argentina	21,885	50,094	71,979	30%	0.45	0.68	1.47
Ukraine	21,081	48,972	70,053	30%	0.41	0.54	1.35
Zambia	2,094	4,919	7,013	30%	0.52	0.57	1.76
Kuwait	17,986	42,957	60,943	30%	0.57	0.59	1.94
Rest of South Asia	476	1,153	1,629	29%	0.34	0.41	1.15

Table A-3
Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports 2007(Tau-1, Tau-2, Tau-3)

	Export Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Sector	Significant Est.	Missing or Non-Significant Est.	Total	% Yes	Tau-1 Missing =0	Tau-2 Non-sig Points Inc.	Tau-3 Exclude Missing Value
Cote d'Ivoire	3,249	7,944	11,193	29%	0.54	0.68	1.86
Rest of Eastern Africa	4,385	10,749	15,134	29%	0.53	1.03	1.83
New Zealand	8,331	21,715	30,045	28%	0.31	0.60	1.11
Rwanda	103	271	374	28%	0.29	0.41	1.06
Lao People's Democratic Republic	330	939	1,269	26%	0.24	0.64	0.91
Russian Federation	98,071	286,551	384,622	25%	0.44	0.51	1.73
Zimbabwe	1,100	3,423	4,522	24%	0.34	1.04	1.39
Uganda	408	1,320	1,727	24%	0.29	1.02	1.22
Rest of Former Soviet Union	3,718	12,436	16,154	23%	0.45	0.70	1.94
Tanzania	795	2,732	3,527	23%	0.26	3.45	1.16
Australia	37,177	137,294	174,471	21%	0.29	1.16	1.34
Norway	32,333	121,904	154,237	21%	0.24	0.29	1.16
Peru	6,439	24,800	31,238	21%	0.29	2.52	1.43
United Arab Emirates	31,823	129,083	160,906	20%	0.30	0.75	1.50
Venezuela	15,237	63,915	79,152	19%	0.35	0.40	1.84
Malawi	224	947	1,171	19%	0.18	0.31	0.93
Cameroon	1,057	4,585	5,641	19%	0.40	0.47	2.12
Ghana	1,097	5,154	6,251	18%	0.23	4.29	1.30
Rest of Western Asia	12,080	62,981	75,062	16%	0.19	0.33	1.20
Chile	10,518	58,585	69,104	15%	0.24	0.46	1.61
Botswana	676	3,805	4,480	15%	0.14	0.38	0.90
Saudi Arabia	56,587	321,973	378,561	15%	0.27	0.29	1.79
Ethiopia	323	1,961	2,283	14%	0.11	1.41	0.79
Guinea	364	2,319	2,683	14%	0.22	1.78	1.61
Rest of Oceania	1,757	11,783	13,540	13%	0.12	1.38	0.96
Mozambique	623	4,388	5,011	12%	0.18	0.26	1.43
Oman	3,313	24,754	28,067	12%	0.17	0.21	1.40
Namibia	617	4,644	5,261	12%	0.15	0.43	1.32

Table A-3

Missing Values and Per Day Ad Valorem Time Cost Estimates by Country and Region Trade Weighted by Exports 2007(Tau-1, Tau-2, Tau-3)

	Export Value with Significant Hummels' HS4 Estimate (Millions of US$)				*Ad valorem* Value of One Day*		
GTAP Sector	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	2,479	19,254	21,733	11%	0.21	0.22	1.85
Bolivia	641	4,990	5,632	11%	0.12	0.50	1.04
Rest of Western Africa	1,075	8,608	9,683	11%	0.12	2.33	1.11
Qatar	5,141	44,997	50,138	10%	0.19	0.21	1.89
Kazakhstan	5,399	47,653	53,052	10%	0.15	0.41	1.50
Mongolia	228	2,048	2,276	10%	0.10	1.90	0.96
Paraguay	472	4,265	4,737	10%	0.09	0.44	0.93
Burkina Faso	47	446	493	10%	0.13	0.98	1.32
Rest of North Africa	11,948	114,625	126,573	9%	0.18	0.21	1.94
Iran Islamic Republic of	8,616	91,246	99,862	9%	0.14	0.17	1.59
Rest of Southeast Asia	1,221	13,480	14,700	8%	0.06	0.07	0.70
Nigeria	4,838	79,990	84,828	6%	0.10	0.11	1.68
Central Africa	1,378	30,484	31,862	4%	0.06	0.08	1.45
South Central Africa	1,204	47,952	49,155	2%	0.04	0.04	1.47