Distance Measures between Free Trade and Autarky for the World Economy *

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Abstract

We develop a methodology to determine numerically how globalized the world economy is motivated by the recent use in popular magazines such as the Economist and Foreign Affairs of Measures of globalization for individual economies. We argue that such indices are hard to interpret for individual economies, and measures are more meaningful for a combined global economy. We present a global general equilibrium model capturing major OECD economies and a residual rest of world for which alternative metrics of distance between observed, free trade and autarky equilibria can be developed. We use data for 2000 and report a number of distance measures between the 2000 observed trade restricted equilibrium and both free trade and autarky equilibria noting the absence of prior literature on metrics of distance between equilibria. The measures are used to determine the degree to which the world economy is globalized by reporting relative distance measures between free trade and autarky.

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1 Introduction

Popular magazines such as the Economist and Foreign Affairs now report each year indices showing how globalized individual economies are. They typically focus on such measures as the ratio of trade to GDP. Trade theory stresses that these measures are hard to evaluate for individual economies, since large economies may have little change in behaviour when they remove their own barriers to trade, but these will greatly affect economic activity in smaller economies. Instead, the question should perhaps be how globalized is the world economy? One way to answer that question is to assess how far the world economy is between autarky and free trade. Here we develop methodologies to answer that question numerically, using welfare, price and quantity distance measures. Broader issues are raised by the distance measures we construct since the main focus of prior general equilibrium literature is on comparative statics and issues of existence, uniqueness, and stability (see Arrow and Hahn (1971), and Mas-Colell (1985)) not measures of distance between equilibria [1]. Our discussion builds on but goes substantially beyond that of distance measure from free trade for individual economies in Riezman, Whalley and Zhang (2004).

We use a global general equilibrium model and data for 2000 for ten OECD countries (Australia, Canada, Germany, Italy, Japan, Korea, Mexico, Norway, UK, US) and a residual rest of world to calculate distance metrics for existing trade restricted global equilibria relative to both autarky and free trade. The countries we consider vary by size, level of income per capita, trade pattern, and size of trade barriers. Alternative distance metrics behave in different ways, and no unambiguously preferred metric seemed to offer itself despite the growing importance attached to distance metrics in more popular globalization debate. Also, the treatment of trade imbalances in the observed trade restricted equilibria influences results.

One feature of results is that with endogenous global prices as trade and other barriers are removed or modified little change in domestic prices need occur for large economies and so they are in this sense already close to free trade. Distances from free trade for large economies may be small even if their own barriers are large. Small economies will effectively integrate into larger economies if all barriers to trade are removed globally, and so distance measures can be large even if their own barriers are small. Thus barriers in foreign markets influence the distance between free trade and autarky for any given economy as well as (and in some cases more so than) barriers employed at home. Also, small economies which in the presence of trade have consumption and production of sharply differing composition can suffer large losses moving to autarky if the domestic production frontier has significant curvature.

[1] Measures of distance between equilibria are also critical in a number of other subareas of economics. In calibration, for instance, inexact calibration (see Dawkins, Srinivasan, and Whalley (2001)) involves choosing parameter values for equilibrium structures so as to produce model generated equilibria as close as possible to observed data (pre-adjusted for compatibility with model equilibrium conditions), and closely related metrics of distance between equilibria are also needed here.

2 Distance Measures between Free Trade and Autarky for the Global Economy

Several possible distances measure suggest themselves in any assessment of how close or far away a current trade restricted equilibrium for the world economy is either from that which would characterize full integration by all economies into the global economy (free trade) or autarky for each economy. The task is to compare an observed global trade (or factor flow) restricted equilibrium to unobserved full integration or autarky equilibria. The general presumption is that with lower trade barriers in the global economy as they have fallen under GATT / WTO negotiating rounds, the global economy is closer to free trade than to autarky. Is this so?

To construct measures of distance between these equilibria, we first calibrate a model of global trade, production and consumption by region to data in the presence of trade restrictions, and then use the model parametrization generated in this way to compute the unobservable global free trade and autarky equilibria. We thus compute the two unobservable equilibria, and our distance measures involve pairwise equilibrium comparisons to a base case equilibrium. We make the strong assumption that the free trade, autarky, and observed trade restricted equilibria are unique. [2]

We first construct measures of distance between (computed) free trade, autarky, and (observed) trade restricted global equilibria based on welfare metrics such as Hicksian compensating and equivalent variants. How to take into account trade imbalances is a key issue here. We then construct a second class of measures by summing the squares of differences across equilibria in endogenous variables (prices, quantities). There are also a number of difficulties which arise with these measures. One is that if price variables are involved measures are not invariant to alternative price normalizations. Another is that the rationale for including all variables in such measures (such as both prices and quantities) is not clear, while neither is it clear whether some variables should be excluded. Another is that one can have pairs of equilibria for this class of measures which yield sharp differences in distance measures (close, far) in prices and quantities. Also, if only a subset of variables are included in such measures one has to rationalize which they are and why they should be so used. These metrics could also involve exogenous variables such as endowments.

We then construct a third type of distance measure by computing excess demands in the neighborhood of one equilibrium using the equilibrium prices associated with other equilibria. The absolute size of excess demands relative to total demands then yields the distance measure. We calibrate our global model using data generated in the presence of trade barriers and then introduce computed free trade equilibrium prices into the calibrated model parameterzation in the presence of trade barriers and compute global excess demands (i.e. the sum of country imports and exports). The distance measure this yields is the absolute value of global excess demands generated in this way relative to total global demands. These

[2] See the discussion of the likelihood of multiplicity of equilibria in models similar to those we use in Kehoe (1991) and Whalley and Zhang (2004).

are model dependent measures in that the numerical value of the distance measure will vary with the underlying model parametrization generated by calibration to observed equilibrium data in the presence of country trade barriers (say, as elasticities of substitution and share parameters in CES functions used in calibration to the same data set change). Other problems arise with these types of measures. One is that these measures are only easy to use where there are point-to-point mappings, not correspondences.

Finally we use a fourth global distance measure which we construct in model parameter space, and which is motivated by the Debreu (1951) coefficient of resource utilization. This measure yields an estimate of the maximum proportional uniform shrinkage in the endowments of all economies in the global economy which can be achieved subject to the constraint that global utility (in the form of a global social welfare function) is preserved as trade barriers are removed. Ideally these measures should all yield a consistent measure of how globalized the world economy is as a whole. If they are not consistent these is no obvious way of choosing between these measures, and no single measure dominates all others.

To formalize this discussion we consider the case of a global economy with N countries, 2 produced goods in each country and 1 mobile factor (labour) in production of each good, and decreasing returns to scale. This form of production structure is used so as to avoid the specialization problems that arise in numerical trade models of the Hecksher-Ohlin form as discussed by Johnson (1966), and Abrego and Whalley (2003). We assume that products are homogeneous across countries, and thus are closer to pure theory models of trade rather than the Armington type heterogenrous product models used in numerical simulation models (see Whalley (1985)). Such a treatment is also needed for autarky equilibria to be well defined. We further assume that there are various features which limit the integration of national economies into the global economy, such as tariffs, domestic taxes, quotas and other policy interventions, and that these are present in the observed trade restricted equilibrium but absent in a hypothetical globally integrated free trade equilibrium. Because of the production structure we use, neither free trade nor autarky equilibria will involve specialization and so computation of unobserved equilibrium is relatively straight forward.

For each country n we assume production functions for the two goods to be given by

$$Q_{nj} = \phi_{nj} L_{nj}^{\delta_{nj}}, \qquad j = 1, 2 \tag{1}$$

where Q_{nj} denotes output of the j-th industry, L_{nj} is the labor input, ϕ_{nj} is the scale or units parameter, and $\delta_{nj} < 1$ is the distribution parameter.

World prices for goods are P_{0j} and are endogenous to the model. The trade barriers on imports of goods j in country n are assumed to be represented by the tariff rates r_{nj}. $r_{nj} > 0$ if good j is imported ($X_{nj} > Q_{nj}$), and $r_{nj} = 0$ if good j is exported ($X_{nj} \leq Q_{nj}$). The domestic price of good j is $P_{nj} = (1 + r_{nj})P_{0j}$.

The wage rate w_n in country n equals the value marginal product of labour in the sector, i.e.

$$w_n = P_{nj}\frac{\partial Q_{nj}}{\partial L_{nj}} = \phi_{nj}\delta_{nj}P_{nj}L_{nj}^{\delta_{nj}-1}, \qquad j=1,2. \tag{2}$$

On the demand side of each economy we consider a representative consumer with a Cobb-Douglas utility function given by

$$U_n = \prod_{j=1,2} X_{nj}^{\alpha_{nj}} = X_{n1}^{\alpha_{n1}} X_{n2}^{\alpha_{n2}} \tag{3}$$

where X_{nj} is the quantity of good j demanded by the consumer, and α_{nj} is the share parameter ($\sum_{j=1,2}\alpha_{nj} = 1$).

Consumer income in each economy has four parts: endowment income $w_n E_n$; profits $\sum_{j=1,2} P_{nj}Q_{nj}$ $-w_n E_n$; tariff revenues $R_n = \sum_{j=1,2} r_{nj}P_{0j}Z_{nj}$; and an exogenous foreign resource transfer $B_n = \sum_{j=1,2} P_{0j}Z_{nj}$ financing the trade imbalance [3].

$$I_n = w_n E_n + \left[\sum_{j=1,2} P_{nj}Q_{nj} - w_n E_n\right] + R_n + B_n = \sum_{j=1,2} P_{nj}Q_{nj} + R_n + B_n \tag{4}$$

where E_n is the consumer's endowment of labor, and $Z_{nj} = X_{nj} - Q_{nj}$ are imports and exports of good j (excess demands for goods).

The consumer budget constraint in country n is

$$\sum_{j=1,2} P_{nj}X_{nj} = I_n \tag{5}$$

where P_{nj} is the consumer price for good j.

Demand functions from utility maximizing behaviour are

$$X_{nj} = \frac{\alpha_{nj}I_n}{P_{nj}}, \qquad j=1,2. \tag{6}$$

A global equilibrium in this model is such that world demand equals world supply for goods and labour markets clear in each country. More explicitly these equilibrium conditions are that

[1] Demand equal supply for goods in the world

$$\sum_{n=1,\cdots,N} X_{nj} = \sum_{n=1,\cdots,N} Q_{nj}, \qquad j=1,2; \tag{7}$$

[2] Demand equal supply for labour in each country

$$\sum_{j=1,2} L_{nj} = E_n, \qquad n=1,\cdots,N. \tag{8}$$

A global equilibrium is characterized by wage rate w_n, and world prices P_{01} and P_{02}, such that excess demands for goods in the world are zero, and excess demands for labour in each country are zero.

[3] We incorporate the trade imbalance in this way since actual data used in model calibration for individual economies are not consistent with zero trade balance.

At such an equilibrium imports and exports for each country can differ in value terms if the trade imbalance is equal to B_n in each country is financed by transfers from broad and is treated as exogenous and fixed. As the base case data we calibrate to has these trade imbalances, we allow for non-zero trade imbalances in the model. In this case the budget constraint for each country can be written, from equation (4), as

$$\sum_{j=1,2} P_{nj} X_{nj} = \sum_{j=1,2} P_{nj} Q_{nj} + R_n + B_n, \tag{9}$$

that is,

$$\sum_{j=1,2} (1 + r_{nj}) P_{0j} Z_{nj} = \sum_{j=1,2} P_{nj} Z_{nj} = \sum_{j=1,2} r_{nj} P_{0j} Z_{nj} + B_n. \tag{10}$$

where $Z_{nj} = X_{nj} - Q_{nj}$ for $j = 1, 2$ and $n = 1, \cdots, N$. This implies

$$\sum_{j=1,2} P_{0j} Z_{nj} = B_n. \tag{11}$$

An autarky equilibrium for each country is characterized by market demand equaling market supply for goods and labour inputs, i.e.

[1] Demand equal supply for goods in country n

$$X_{nj} = Q_{nj}, \qquad j = 1, 2; \tag{12}$$

[2] Demand equal supply for labour in country n

$$\sum_{j=1,2} L_{nj} = E_n. \tag{13}$$

These country equilibria are characterized by a country wage rate w_n, and domestic prices P_{n1} and P_{n2}, such that equations (12) and (13) hold.

For this model we consider three different equilibria: an observed equilibrium in the presence of barrier restrictions in each country, a free trade equilibrium, and an autarky equilibrium in which there is no trade between countries.

Assuming for now that all 3 equilibria in this model are unique, we can construct alternative pairwise equilibrium comparisons between equilibrium pairs. We label any pair of equilibria as $\Xi^{(1)}$ and $\Xi^{(2)}$. Typically we have an observed equilibrium $\Xi^{(1)}$ and a model parametrization calibrated to this and another equilibrium $\Xi^{(2)}$ computed as a counterfactual equilibrium. These two equilibria are characterized by the endogenous variables $(P_{0j}^{(1)}, w_n^{(1)}, P_{nj}^{(1)}, Q_{nj}^{(1)}, L_{nj}^{(1)}, X_{nj}^{(1)})$ and $(P_{0j}^{(2)}, w_n^{(2)}, P_{nj}^{(2)}, Q_{nj}^{(2)}, L_{nj}^{(2)}, X_{nj}^{(2)})$ for $n = 1, \cdots, N$ and $j = 1, 2$.

Conventional welfare measures across pairs of equilibria can be constructed to yield Hicksian equivalent or compensating variations of the welfare changes involved using the country utility functions and the price changes involve. These have to be modified in light of the trade imbalances in the benchmarch equilibrium which disappear in autarky. This involves using a modified measure of Hicksian welfare change in which any change in trade imbalance is added to the conventional welfare measure. This is discussed in more detail later. Distance metrics of the Debreu type require a global social welfare function, and in this case global utility is taken, for simplicity, to be additive in utility across the N countries, i.e. $U = \sum_{n=1,\cdots,N} \lambda_n U_n$ with share parameters for each country given as

$$\lambda_n = \frac{Q^0_{n1} + Q^0_{n2}}{\sum_{n=1,\cdots,N}(Q^0_{n1} + Q^0_{n2})}. \tag{14}$$

Normalized **Euclidean distance measures** between pairs of equilibria for each country in prices and quantities can also be constructed as

$$M_{wn} = \frac{|w_n^{(1)} - w_n^{(2)}|}{\frac{1}{2}\sum_{m=1,2} w_n^{(m)}} \tag{15}$$

$$M_{Pn} = \frac{\sqrt{\sum_{j=1,2}\left[P_{nj}^{(1)} - P_{nj}^{(2)}\right]^2}}{\frac{1}{4}\sum_{m=1,2}\sum_{j=1,2} P_{nj}^{(m)}} \tag{16}$$

$$M_{Qn} = \frac{\sqrt{\sum_{j=1,2}\left[Q_{nj}^{(1)} - Q_{nj}^{(2)}\right]^2}}{\frac{1}{4}\sum_{m=1,2}\sum_{j=1,2} Q_{nj}^{(m)}} \tag{17}$$

$$M_{Ln} = \frac{\sqrt{\sum_{j=1,2}\left[L_{nj}^{(1)} - L_{nj}^{(2)}\right]^2}}{\frac{1}{4}\sum_{m=1,2}\sum_{j=1,2} L_{nj}^{(m)}} \tag{18}$$

$$M_{Xn} = \frac{\sqrt{\sum_{j=1,2}\left[X_{nj}^{(1)} - X_{nj}^{(2)}\right]^2}}{\frac{1}{4}\sum_{m=1,2}\sum_{j=1}^{2} X_{nj}^{(m)}} \tag{19}$$

We can also compute global **Euclidean distance measures** of prices and quantities for pairs of equilibria as

$$M_{P0} = \frac{\sqrt{\sum_{j=1,2}\left[P_{0j}^{(1)} - P_{0j}^{(2)}\right]^2}}{\frac{1}{4}\sum_{m=1,2}\sum_{j=1,2} P_{0j}^{(m)}} \tag{20}$$

$$M_{Q} = \frac{\sqrt{\sum_{j=1,2}\left\{\sum_{n=1,\cdots,N}\left[Q_{nj}^{(1)} - Q_{nj}^{(2)}\right]\right\}^2}}{\frac{1}{4}\sum_{m=1,2}\sum_{j=1}^{2}\sum_{n=1,\cdots,N} Q_{nj}^{(m)}} \tag{21}$$

$$M_{X} = \frac{\sqrt{\sum_{j=1,2}\left\{\sum_{n=1,\cdots,N}\left[X_{nj}^{(1)} - X_{nj}^{(2)}\right]\right\}^2}}{\frac{1}{4}\sum_{m=1,2}\sum_{j=1}^{2}\sum_{n=1,\cdots,N} X_{nj}^{(m)}} \tag{22}$$

We also construct global **excess demand measures** between equilibria: $\Xi^{(1)}$ and $\Xi^{(2)}$ and the associated variable equilibrium values: $(P_{0j}^{(1)}, w_n^{(1)}, P_{nj}^{(1)}, Q_{nj}^{(1)}, L_{nj}^{(1)}, X_{nj}^{(1)})$ and $(P_{0j}^{(2)}, w_n^{(2)}, P_{nj}^{(2)}, Q_{nj}^{(2)}, L_{nj}^{(2)}, X_{nj}^{(2)})$ for $n = 1, \cdots, N$ and $j = 1, 2$ by assuming $\Xi^{(1)}$ is observed, and then introducing prices from $\Xi^{(2)}$ into the model parametrization supporting $\Xi^{(1)}$ and computing excess demands. This procedure does not yield an equilibrium solution to the model, but does indicate locally how large excess demands for goods (i.e. trade) would be were characteristics of $\Xi^{(2)}$ (free trade or autarky) to be introduced into the model parameterization supporting $\Xi^{(1)}$.

To construct excess demand measures in goods space for each country and hence across all countries, we introduce the world prices $P_{0j}^{(2)}$ into model supporting equilibrium $\Xi^{(1)}$, and then solve for $P_{nj}^{(1')}$, $w_n^{(1')}$ and $L_{nj}^{(1')}$ hence $Q_{nj}^{(1')}$ from Equations (1), (2) and (9) (or (14)).

Consumer's income is given from (4) as

$$I_n^{(1')} = \sum_{j=1,2} P_{nj}^{(2)} Q_{nj}^{(1')} + \sum_{j=1,2} r_{nj}^{(1)} P_{0j} Z_{nj}^{(1')} + B_n \tag{23}$$

where $Z_{nj}^{(1')} = X_{nj}^{(1')} - Q_{nj}^{(1')}$.

Solving for consumption $X_{nj}^{(1')}$ from (6), for $j = 1, 2$, yields

$$X_{nj}^{(1')} = \frac{\alpha_{nj}}{P_{nj}^{(2)}} \left\{ \sum_{j=1,2} P_{nj}^{(2)} Q_{nj}^{(1')} + \sum_{j=1,2} r_{nj}^{(1)} P_{0j} \left[X_{nj}^{(1')} - Q_{nj}^{(1')} \right] + B_n \right\} \tag{24}$$

We can also generate a global excess demand distance measure between $\Xi^{(1)}$ and $\Xi^{(2)}$ using goods excess demands $Z_{nj}^{(1')}$. This yields a goods excess demand measure of distance for country n as

$$R_{Gn}^{(1)} = \frac{\sum_{j=1,2} P_{nj}^{(1')} |Z_{nj}^{(1')}|}{\sum_{j=1,2} P_{nj}^{(1')} X_{nj}^{(1')}} \tag{25}$$

Global **excess demand measures** in goods space between economies are calculated by introducing the world prices $P_{0j}^{(2)}$ into the model supporting equilibrium $\Xi^{(1)}$. To yield the domestic good prices $P_{nj}^{(1')}$,

$$P_{nj}^{(1')} = (1 + r_{nj}^{(1)}) P_{0j}^{(2)}. \tag{26}$$

We solve for $w_n^{(1')}$ and $L_{nj}^{(1')}$ hence $Q_{nj}^{(1')}$ from Equations (1), (2) and (12) and obtain consumer income $I_n^{(1')}$ and consumption $X_{nj}^{(1')}$ in equations (23) and (24), and hence goods excess demands $Z_{nj}^{(1')}$. This yields a single goods excess demand measure of distance between $\Xi^{(1)}$ and $\Xi^{(2)}$ as

$$R_G^{(1)} = \frac{\sum_{n=1,\cdots,N} \sum_{j=1,2} P_{nj}^{(1')} |Z_{nj}^{(1')}|}{\sum_{n=1,\cdots,N} \sum_{j=1,2} P_{nj}^{(1')} X_{nj}^{(1')}}. \tag{27}$$

Finally we construct **Debreu type shrinkage measures** of distance between the two global equilibria: $\Xi^{(1)}$ and $\Xi^{(2)}$ and their characteristics: $(P_{0j}^{(1)}, w_n^{(1)}, P_{nj}^{(1)}, Q_{nj}^{(1)}, L_{nj}^{(1)}, X_{nj}^{(1)})$ and $(P_{0j}^{(2)}, w_n^{(2)}, P_{nj}^{(2)}, Q_{nj}^{(2)}, L_{nj}^{(2)}, X_{nj}^{(2)})$ for $n = 1, \cdots, N$ and $j = 1, 2$. To do this we use $P_{0j}^{(2)}$ in the model specification supporting Economy $\Xi^{(1)}$, and compute a free trade equilibrium for the case where trade barriers are eliminated in all countries and there are supporting endowments of factors $E_n^{(1')} = [1 + R_{Dn}^{(1)}] E_n^{(1)}$ which yields unchanged utility for each country representative consumer n. $R_{Dn}^{(1)}$ yields the Debreu type shrinkage measure of distance for country n between the two equilibria $\Xi^{(1)}$ and $\Xi^{(2)}$. For the global economy, there is a supporting scalar adjustment of endowments of factors $E_n^{(1')} = [1 + R_D^{(1)}] E_n$ (for all $n = 1, \cdots, N$)

which yields unchanged global utility. $R_D^{(1)}$ yields the Debreu type shrinkage measure of distance between the two equilibria $\Xi^{(1)}$ and $\Xi^{(2)}$. A similar calculation can be made for the autarky case, but here there are separate scalar adjustments endowments for each economy.

3 Calculating Distance Metrics for the Global Economy

To calculate pairwise distance measures between observed free trade and autarky equilibria, we use a Ricardian 2 good, 1 factor per country global trade model (as set out above) and construct alternative distance measures using a model of the global economy involving the larger OECD economies and a residual rest of world (ROW). We treat Australia, Canada, Germany, Italy, Japan, Korea, Mexico, Norway, UK, US as separate OECD economies which differ in size, trade patterns, levels of development, and their degree of openness and add a residual rest of the world yielding a 10 region model. We use the OECD STAN database for 2000 as the foundation for the construction of an observed trade restricted equilibrium for the global economy. This provides consistent data on consumption, production, and trade for all OECD economics and into this we introduce measures of average tariff rates on imports also taken from OECD sources. This OECD data is simpler for us to use for our purpose and is in some ways more applicable to our needs than the GTAP data base currently widely used by trade equilibrium modellers.

The initial base case equilibrium in the resulting global data set reflecting an equilibrium for each of these economies in the presence of domestic trade restrictions is set out in Table 1. We have generated this by taking information from the STAN database in value terms in domestic currency, from which we assemble data on consumption, production, factor by sector, and net trade for each country for the year 2000.

We then consider two aggregate traded goods sectors which we take to reflect manufacturing and non-manufacturing activity. In using this two sector classification for each economy, we ignore all service related and non-tradable transactions such as utilities, government activity, retailing, wholesaling, distribution, banking, and financial services. From the STAN data, "total manufacturing" is taken as manufacturing and "agriculture, fishing, forestry, and mining / quarrying" are taken as non-manufacturing.

Table 1 Value Data Reflecting An Assumed 2000 Benchmark Equilibria for a Sample of OECD Economies and a Residual ROW[1] (Country Data in Domestic Currency[2])

	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Value of Output											
NM[3]	55,593	82,908	27,750	35,534	7,772	26,320	272,188	358,559	34,109	267,362	217,295
M[3]	73,354	198,899	423,220	220,604	112,114	163,283	1,013,597	141,778	153,671	1,520,263	1,320,615
Value of Factor Use											
L[3] - NM	10,505	20,227	15,870	8,314	2,382	3,115	51,105	25,061	6,163	89,190	59,861
L[3] - M	40,296	104,127	310,640	122,207	59,506	59,670	311,239	97,660	110,483	981,781	789,650
K[3] - NM	45,088	62,681	11,880	27,220	5,390	23,205	221,083	333,498	27,946	178,172	157,434
K[3] - M	33,058	94,772	112,580	98,397	52,608	103,613	702,358	44,118	43,188	538,482	530,964
Value of Net Trade (Imports - Exports)											
NM	-23,421	-34,043	48,333	26,554	9,604	42,072	-131,025	-305,955	-0,325	89,103	-155,999
M	49,096	-1,329	-120,091	-37,996	-19,178	-57,401	145,532	78,985	36,799	321,348	-34,893
Value of Consumption											
NM	32,172	48,865	76,083	62,088	17,376	68,392	141,163	52,604	33,784	356,465	61,297
M	122,450	197,570	303,129	182,608	92,936	105,882	1,159,129	220,763	190,470	1,841,611	1,285,722
Exchange Rate (USDs Equivalent to 1 Unit Local Currency)											
	0.581567	0.673166	0.923392	0.923392	0.009275	0.000884	0.105719	0.113496	1.515850	1.000000	1.000000
Initial Tariff Rate on Imports[4]											
NM	0.000000	0.000000	0.208675	0.208675	0.158008	0.368725	0.000000	0.000000	0.000000	0.109535	0.000000
M	0.105931	0.000000	0.000000	0.000000	0.000000	0.000000	0.348223	0.032875	0.041334	0.033641	0.000000

1 Sources: OECD STAN database plus Table 2. 2 These value units in domestic currency are AUD 10^6, CAD 10^6, EUR 10^6, EUR 10^6, JPY 10^9, KRW 10^9, MXP 10^6, NWK 10^6, GBP 10^6, USD 10^6, and USD 10^6. 3 In this table, M and NM denote Total Manufacturing and Non Manufacturing (Agriculture, Hunting, Forestry and Fishing; Mining and Quarrying); L and K denote Labour and Capital. 4 See Table 2 for the underlying data used to generate tariff averages reputed here.

STAN data yield value added for this sectoral classification, and also data on compensation of employees by sectors. The return by sector to an assumed fixed factor in each country is constructed by residual as the difference between the two. We make the strong assumption that the output of each sector is given only by the value added originating in the sector, and ignore all intermediate transactions. This yields data on output and factor use by sector in value terms for each country for our benchmark year. This data is in value terms. To produce equilibrium data on both prices and quantities we need to adopt a units convention for the measurement of both goods and factors. We follow the convention attributed to Harberger (1962) and discussed in Shoven and Whalley (1992) of assuming unitary prices for factors, and unitary world prices for goods in the observed trade distorted equilibrium. This yields domestic prices for imports as one plus the trade barrier (tariff) rate.

Given our use of a model with homogeneous products across countries, we use the trade data in STANs on a net trade basis netting out imports and exports by good (in value terms) for our 2 sector classification for each country. This yields consumption as production plus net trade. This substantially reduces trade volumes as they appear in each country model relative to published trade data. Most of the OECD economies we consider are net exporters of manufactured goods. Trade balance does not hold in this net trade data since some countries have trade surpluses and others (notably the US) have deficits. Rather than modify the data to force trade balance we use a model which incorporates a fixed trade imbalance (which is non-zero). For the US, this yields the feature that both goods are imported and financed by foreign resource transfers supporting the observed trade imbalance.

Trade barriers (tariffs rate data) are from OECD sources and are used as our trade barrier representation in the observed equilibrium. [4] Table 2 which reports the barrier data is from OECD Sources which report bound tariff rates by Harmonized Nomenclature section headings, and gives the fraction of line items in specified tariff lines falling in numerical ranges of tariff rates. We use statutory rather than effective tariff rates, and we aggregate this data using simple means for in sample ranges. We do not employ trade weighted average, nor use applied rather than bound tariff rates. There is a considerable literature on constructing tariff averages, which for simplicity we ignore.

[4] This data is also used by Riezman, Whalley and Zhang (2004).

Table 2 OECD Data on Tariff Intervals by HS Section (Post-Uruguay Round Bound Rates) by Country Used to Calculate Country Tariff Rates in Table 1[1] [2]

(% of Tariff Nomenclature Section Headings in Specified Rate Ranges by Country)

Tariff Binding Ranges	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US
Non Manufacturing										
Duty Free	32.6	42.1	26.5	26.5	31.0	2.2	0.1	23.4	26.5	27.9
0 – 5%	16.2	23.9	16.1	16.1	19.1	8.4	3.3	0.9	16.1	16.7
5 – 10%	1.6	0.3	9.3	9.3	6.7	16.6	3.0	0.4	9.3	2.0
10 – 15%	0.0	0.0	7.7	7.7	1.2	19.1	8.4	56.4	7.7	0.1
15 – 20%	44.0	26.6	12.2	12.2	22.0	7.2	0.0	14.3	12.2	48.1
20 – 50%	4.2	6.3	11.2	11.2	10.3	8.1	0.3	0.3	11.2	4.7
> 50%	1.4	0.9	17.0	17.0	9.6	38.6	84.8	4.2	17.0	0.4
Manufacturing										
Duty Free	18.7	28.6	22.2	22.2	53.8	13.5	0.2	44.1	22.2	37.2
0 – 5%	19.6	16.4	43.0	43.0	28.4	7.1	0.0	31.4	43.0	39.6
5 – 10%	28.1	39.5	27.3	27.3	14.5	23.8	0.2	13.7	27.3	15.6
10 – 15%	17.7	8.7	7.0	7.0	2.7	36.8	0.0	10.6	7.0	5.6
15 – 20%	2.5	7.1	0.4	0.4	0.2	8.2	0.3	0.0	0.4	1.3
20 – 50%	11.6	0.2	0.2	0.2	0.4	10.5	99.2	0.0	0.2	0.8
> 50%	1.7	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.0
Calculated Country Average Tariff Rates (Percentage)										
NM	10.7450	8.1469	20.8675	20.8675	15.8008	36.8725	65.1276	12.8729	20.8675	10.9535
M	10.5931	5.7168	4.1334	4.1334	2.3100	11.8107	34.8223	3.2875	4.1334	3.3641

1 Note: Calculations are report 6 - digit HS section headings.

2 Sources: Tariffs and Trade: OECD query and reporting system, OECD 2000.

The benchmark equilibrium in Table 1 is taken as an observed equilibrium. We calibrate the model to this data which we assume to be generated in the presence of trade barriers (tariffs). We then apply the procedures set out in the previous section and construct distance measures for the observed equilibria relative to free trade and autarky. We use these measures to assess how globalized (how far between free trade and autarky) the global economy is.

The procedures set out in Section 2 are relatively simple to implement, but there are a number of issues of detail which arise. One is that in reality there are many barriers beyond tariffs which limit integration of national economies into the global economy including other trade measures (quotas, dumping and countervailing duties), national standards, differential regulation of financial institutions, transportation regulation, agricultural policies, and others. Each of these ideally calls for an explicit model representation which would differ from representation through an advalorem equivalent tariff if they were able to be incorporated into such analyses. Extensions of this approach could be used to analyze how these barriers also affect distance measures.

Table 3 presents the calibrated model parameter values for the global model, along with model data on endowments and tariff rates. The calibration procedures we use are set out in Dawkins, Srinivasan and Whalley (2001). To implement calibration we rely on a literature search to generate substitution elasticities by sector by country, and use values roughly consistent with those reported in Piggott and Whalley (1985) and Hammermesh (1993) of 2.0 in non manufacturing and 0.5 in manufacturing. We use the country model to compute free trade and autarky equilibria. We are then able to then construct sum of squares distance measures between these equilibria as set out in previous section, and use the model parameterizations supporting the observed and counterfactual equilibria to construct excess demand distance measures, and Debreu type shrinkage measures of distance of economies from both autarky and free trade.

Table 3 Calibrated and Other Model Parameter by Country Reproducing the Equilibrium Data in Table 1

	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Scale Parameters in Production											
NM	22.966553	29.515127	4.565987	16.850332	24.105993	15.076619	20.963805	37.827886	34.528627	53.870091	70.384255
M	6.819946	14.471290	6.138498	14.859190	36.448217	33.883787	27.187297	2.971188	5.632877	17.191562	24.450043
Share Parameters in Production											
NM	0.188963	0.243969	0.571892	0.233973	0.306485	0.118351	0.187756	0.069894	0.180685	0.333593	0.275484
M	0.549336	0.523517	0.733992	0.553965	0.530763	0.365439	0.307064	0.688823	0.718958	0.645797	0.597941
Share Parameters in Preferences											
NM	0.208069	0.198288	0.200634	0.253735	0.157517	0.392439	0.108563	0.192430	0.150651	0.162171	0.045505
M	0.791931	0.801712	0.799366	0.746265	0.842483	0.607561	0.891437	0.807570	0.849349	0.837829	0.954495
Initial Endowment of Labour[2]											
	50,801	124,354	326,510	130,521	61,888	62,785	362,344	122,721	116,646	1070,971	849,511
Initial Tariff Rate on Imports[1] (Percentage)											
NM	0.0000	0.0000	20.8675	20.8675	15.8008	36.8725	0.0000	0.0000	0.0000	10.9535	0.0000
M	10.5931	0.0000	0.0000	0.0000	0.0000	0.0000	34.8223	3.2875	4.1334	3.3641	0.0000
Foreign Resource Transfers in Domestic Currency[3]											
	20,972.4	-35,372.0	-80,102.6	-16,026.5	-10,884.5	-26,662.9	-23,081.5	-229,483.9	35,013.3	352,576.6	-190,891.4

1 Model tariff rates on exports are set equal to zero, the US imports both goods, with the trade imbalance financed by a resource transfer from abroad. 2 These value units in domestic currency are AUD 10^6, CAD 10^6, EUR 10^6, EUR 10^6, JPY 10^9, KRW 10^9, MXP 10^6, NWK 10^6, GBP 10^6, USD 10^6, and USD 10^6. 3 Footnote from Table 1.

4 Distance Measures between Observed, Free Trade, and Autarky Equilibria

We have used the 2 good global Ricardian trade model capturing 10 OECD countries and a residual rest of the world to compute free trade and autarky equilibria, following calibration of the model to an observed equilibrium given by the data reported above in Section 3. In this exercise trade barriers are assumed only to apply to imports. Table 4 reports benchmark (2000), free trade and autarky equilibria for the model.

Moving from the benchmark equilibrium to free trade increases the world prices of non-manufacturing goods (P_{01} in Table 4) relative to that of manufacturing goods (P_{02} in Table 4), reflecting the higher trade barriers on non-manufacturing, and specifically in agriculture. Relative prices are the same in all economies in the free trade equilibrium, and the output response matches the trade response as the output of the non-manufacturing sector in manufacturing exporting countries rises, and falls in non-manufacturing exporting countries. The welfare changes track the terms of trade change welfare increases in most countries that experience a terms of trade improvement and fall in the ones whose terms of trade deteriorate. Exceptions are Germany and the UK, but the welfare changes are small in these two cases. Wage rates fall in Australia, Mexico, and UK and go up in the other countries.

The autarky equilibria reveal large changes in both relative goods prices and wage rates by country as compared either to the benchmark equilibrium or free trade. Using computed relative autarky prices, countries with a low relative price of non-manufactured goods such as Mexico, Norway and Australia export the non-manufactured good at the benchmark equilibrium. Countries with high relative prices of non-manufactured goods (Korea, Japan, and Italy for example) import non-manufactured goods at the benchmark equilibrium. There are also large associated production responses by sector and the pattern of consumption changes quite considerably.

Table 4 Benchmark and Free Trade Equilibria for the World and Autarky Equilibrium for All Countries

Country	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Benchmark Equilibrium for the World Economy											
• World Prices $P_{0j} = 1.000000$ for $j = 1, 2$											
• Country Wage Rates $w_n = 1.000000$ for $n = 1, \cdots, 11$											
• Domestic Prices P_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	1.000000	1.000000	1.208675	1.208675	1.158008	1.368725	1.000000	1.000000	1.000000	1.109535	1.000000
M	1.105931	1.000000	1.000000	1.000000	1.000000	1.000000	1.348223	1.032875	1.041334	1.033641	1.000000
• Production Output Q_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	32,331.036	55,810.885	21,200.173	27,146.917	62,246.055	16,996.541	28,775.558	40,695.127	51,704.128	240,967.714	217,295.009
M	38,574.056	133,892.136	390,797.821	203,703.895	1,039,801.526	144,321.766	79,480.079	15,579.118	223,696.009	1,470,783.834	1,320,614.579
• Labour Input L_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	6,109.358	13,616.138	14,654.226	7,677.078	22,091.864	2,753.271	5,402.791	2,844.331	9,342.184	89,190.000	59,861.191
M	23,434.810	70,094.804	286,842.387	112,844.925	551,888.520	52,740.823	32,904.007	11,084.051	167,475.656	981,781.000	789,650.246
• Utility Value U_n for $n = 1, \cdots, 11$											
	49,790.770	100,817.939	204,197.507	122,220.169	646,740.076	69,698.835	74,703.551	18,522.408	214,974.440	1,349,523.071	1,119,443.175
• Consumption X_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	18,710.163	32,894.279	58,125.144	47,433.381	139,164.623	44,165.176	14,923.671	5,970.360	51,211.476	321,274.362	61,296.505
M	64,391.759	132,997.498	279,906.793	168,618.705	861,935.125	93,586.455	90,891.808	24,258.297	277,263.627	1,781,673.096	1,285,721.654
• Income $I_n = \sum_{j=1,2} P_{nj}Q_{nj} + R_n + B_n$ for $n = 1, \cdots, 11$											
	89,923.001	165,891.777	350,161.201	225,950.247	1,023,088.873	154,036.436	137,466.117	31,026.149	339,935.426	2,198,076.000	1,347,018.159
• Tariff Revenue $R_n = \sum_{j=1,2} r_{nj}P_{0j}Z_{nj}$ for $n = 1, \cdots, 11$											
	2,734.893	0.000	7,705.318	4,233.278	12,153.750	10,017.755	3,973.829	285.328	2,214.146	19,255.089	0.000
• Trade Imbalance $B_n = \sum_{j=1,2} P_{0j}Z_{nj}$ for $n = 1, \cdots, 11$											
	12,196.831	-23,811.244	-73,966.058	-14,798.725	-100,947.833	-23,566.675	-2,440.158	-26,045.588	53,074.967	391,195.911	-190,891.429
Free Trade Equilibrium for the World Economy											
• World Prices $P_{01} = 1.112821$ and $P_{02} = 1.034053$											
• Country Wage Rates w_n for $n = 1, \cdots, 11$											
	0.958157	1.042762	1.030818	1.029813	1.032157	1.026181	0.811406	1.010081	0.995293	1.000517	1.037282
• Domestic Prices P_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	1.112821	1.112821	1.112821	1.112821	1.112821	1.112821	1.112821	1.112821	1.112821	1.112821	1.112821
M	1.034053	1.034053	1.034053	1.034053	1.034053	1.034053	1.034053	1.034053	1.034053	1.034053	1.034053
• Production Output Q_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	33,478.137	56,994.372	18,230.311	26,233.924	60,311.190	16,473.545	30,955.346	40,992.436	52,992.628	241,262.389	223,181.241
M	37,441.041	132,664.056	394,191.561	204,746.040	1,041,962.361	144,958.325	77,521.219	15,275.510	222,385.153	1,470,467.117	1,314,506.068
• Labour Input L_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	7,347.270	14,839.090	11,255.155	6,632.788	19,929.044	2,114.271	7,971.086	3,156.535	10,705.657	89,517.352	65,960.198
M	22,196.898	68,871.852	290,241.458	113,889.216	554,051.340	53,379.822	30,335.711	10,771.847	166,112.182	981,453.648	783,551.239
• Utility Value U_n for $n = 1, \cdots, 11$											
	50,354.949	102,404.292	204,306.310	121,817.109	645,396.082	69,565.150	76,328.648	20,665.163	214,099.671	1,337,471.190	1,134,813.904
• Consumption X_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	16,485.136	31,502.142	63,812.387	51,556.257	147,720.515	51,014.771	10,942.742	6,115.754	46,299.582	317,723.155	57,933.077
M	67,523.632	137,071.046	273,607.116	163,183.429	850,271.305	84,995.379	96,698.467	27,621.042	280,915.128	1,766,495.003	1,307,736.904
• Income $I_n = \sum_{j=1,2} P_{nj}Q_{nj} + R_n + B_n$ for $n = 1, \cdots, 11$											
	88,168.050	176,795.019	353,936.108	226,113.265	1,043,612.370	144,660.073	112,168.686	35,367.364	342,004.399	2,180,219.240	1,416,738.773
• Tariff Revenue $R_n = \sum_{j=1,2} r_{nj}P_{0j}Z_{nj} = 0$ for $n = 1, \cdots, 11$											
• Trade Imbalance $B_n = \sum_{j=1,2} P_{0j}Z_{nj}$ for $n = 1, \cdots, 11$											
	12,196.831	-23,811.244	-73,966.058	-14,798.725	-100,947.833	-23,566.675	-2,440.158	-26,045.588	53,074.967	391,195.911	-190,891.429

Table 4 Benchmark and Free Trade Equilibria for the World and Autarky Equilibrium for All Countries

Country	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Benchmark Equilibrium for the World Economy											
• World Prices $P_{0j} = 1.000000$ for $j = 1, 2$											
• Country Wage Rates $w_n = 1.000000$ for $n = 1, \cdots, 11$											
• Domestic Prices P_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	1.000000	1.000000	1.208675	1.208675	1.158008	1.368725	1.000000	1.000000	1.000000	1.109535	1.000000
M	1.105931	1.000000	1.000000	1.000000	1.000000	1.000000	1.348223	1.032875	1.041334	1.033641	1.000000
• Production Output Q_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	32,331.036	55,810.885	21,200.173	27,146.917	62,246.055	16,996.541	28,775.558	40,695.127	51,704.128	240,967.714	217,295.009
M	38,574.056	133,892.136	390,797.821	203,703.895	1,039,801.526	144,321.766	79,480.079	15,579.118	223,696.009	1,470,783.834	1,320,614.579
• Labour Input L_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	6,109.358	13,616.138	14,654.226	7,677.078	22,091.864	2,753.271	5,402.791	2,844.331	9,342.184	89,190.000	59,861.191
M	23,434.810	70,094.804	286,842.387	112,844.925	551,888.520	52,740.823	32,904.007	11,084.051	167,475.656	981,781.000	789,650.246
• Utility Value U_n for $n = 1, \cdots, 11$											
	49,790.770	100,817.939	204,197.507	122,220.169	646,740.076	69,698.835	74,703.551	18,522.408	214,974.440	1,349,523.071	1,119,443.175
• Consumption X_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	18,710.163	32,894.279	58,125.144	47,433.381	139,164.623	44,165.176	14,923.671	5,970.360	51,211.476	321,274.362	61,296.505
M	64,391.759	132,997.498	279,906.793	168,618.705	861,935.125	93,586.455	90,891.808	24,258.297	277,263.627	1,781,673.096	1,285,721.654
• Income $I_n = \sum_{j=1,2} P_{nj}Q_{nj} + R_n + B_n$ for $n = 1, \cdots, 11$											
	89,923.001	165,891.777	350,161.201	225,950.247	1,023,088.873	154,036.436	137,466.117	31,026.149	339,935.426	2,198,076.000	1,347,018.159
• Tariff Revenue $R_n = \sum_{j=1,2} r_{nj}P_{0j}Z_{nj}$ for $n = 1, \cdots, 11$											
	2,734.893	0.000	7,705.318	4,233.278	12,153.750	10,017.755	3,973.829	285.328	2,214.146	19,255.089	0.000
• Trade Imbalance $B_n = \sum_{j=1,2} P_{0j}Z_{nj}$ for $n = 1, \cdots, 11$											
	12,196.831	-23,811.244	-73,966.058	-14,798.725	-100,947.833	-23,566.675	-2,440.158	-26,045.588	53,074.967	391,195.911	-190,891.429
Autarky Equilibria for Individual Economies											
• Country Wage Rates w_n for $n = 1, \cdots, 11$											
	1.174374	0.852493	0.846672	0.844798	0.711375	0.807805	1.382744	0.930017	1.006582	1.012734	0.781570
• Domestic Prices P_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	0.559486	0.605031	1.720485	1.717356	1.568857	3.325581	0.776425	0.125012	0.844988	1.191156	0.330632
M	1.386569	0.880749	0.818157	0.819425	0.690564	0.739575	1.970797	1.023715	1.051336	1.043714	0.797872
• Production Output Q_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	27,201.526	49,964.902	42,436.927	31,819.082	82,746.936	19,704.224	25,181.752	34,998.527	49,746.798	248,107.576	156,670.297
M	41,775.533	138,775.884	355,547.776	196,133.162	1,005,461.298	137,170.680	81,461.938	17,936.130	225,418.754	1,462,879.023	1,361,787.416
• Labour Input L_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	2,448.794	8,651.413	49,316.640	15,134.260	55,930.124	9,600.472	2,654.839	0,328.812	7,545.535	97,348.687	18,258.243
M	27,095.374	75,059.530	252,179.973	105,387.743	518,050.260	45,893.621	35,651.959	13,599.570	169,272.304	973,622.313	831,253.193
• Utility Value U_n for $n = 1, \cdots, 11$											
	38,207.869	113,329.748	232,103.368	123,633.126	678,454.073	64,054.813	71,713.693	20,398.358	179,526.832	1,097,095.112	1,234,167.856
• Consumption X_{nj} for $n = 1, \cdots, 11$ and $j = 1, 2$											
NM	27,201.526	49,964.902	42,436.927	31,819.082	82,746.936	19,704.224	25,181.752	34,998.527	49,746.798	248,107.576	156,670.297
M	41,775.533	138,775.884	355,547.776	196,133.162	1,005,461.298	137,170.680	81,461.938	17,936.130	225,418.754	1,462,879.023	1,361,787.416
• Income $I_n = \sum_{j=1,2} P_{nj}Q_{nj} + R_n + B_n$ for $n = 1, \cdots, 11$											
	73,143.523	152,456.990	363,906.060	215,361.119	824,153.522	166,976.020	180,096.656	22,736.720	279,026.208	1,822,361.965	1,138,331.966
• Tariff Revenue $R_n = \sum_{j=1,2} r_{nj}P_{0j}Z_{nj} = 0$ for $n = 1, \cdots, 11$											
• Trade Imbalance $B_n = \sum_{j=1,2} P_{0j}Z_{nj} = 0$ for $n = 1, \cdots, 11$											

4.1 Welfare Comparisons Across Equilibria

While theory suggests to us that countries should always do better at free trade than autarky Table 4 indicates that Canada, Germany, and Italy do better at autarky than free trade. What explains these impacts on country welfare is that they derive from utility calculations in Table 4 in which trade imbalances are ignored. For instance, Table 3 indicates that Canada runs a 35.3720 billion (Canadian) dollar trade surplus and so in free trade, Canada makes a 35.3720 billion (Canadian) dollar transfer to foreigners. In the free trade utility calculation, this transfer is ignored while in autarky there are no trade surpluses or deficits and hence no transfers. So, for countries that have trade surpluses, as Canada, Germany, and Italy do, welfare calculations are biased in favor of autarky. For countries, like the United States, that run trade deficits comparisons between autarky and free trade exaggerate the welfare change given due to deficits in free trade.

Table 4 also indicates that, in autarky, as national economies becomes disconnected are from another, there can be very large impacts on relative prices within economies. This is especially so in Norway where relative prices of non-manufacturing goods are in the order of 1:8 compared to benchmark world prices of 1:1, and in Korea where domestic prices in autarky are on he order of 5:1.

In order to take these trade imbalances into account in welfare comparison between equilibria we compare utility, income and trade imbalances for all countries. From Table 4, Australia, UK and the US run trade deficits while all other countries run trade surpluses. These deficits and surpluses entail claims or liabilities on future consumption and we need to correct our welfare measures to take these into account. In Table 5 we first compute compensating variation (CV) and equivalent variation (EV) measures of welfare gain or loss between pairs of equilibria, ignoring the trade imbalances. Then, we construct modified money metric compensating variation equivalent variation measures (MCV and MEV). These modified measures are computed using the CV and EV measures, but we add trade surpluses to consumption and subtract trade deficits from consumption. Thus we treats a trade surplus as consumption since it is delayed future consumption and trade deficits as a subtraction from consumption since they represent future liabilities or borrowing. Comparing between benchmark and free trade equilibria because MCV and MEV measures are the same trade imbalances do not change, but between autarky and benchmark (or free trade) equilibria changes occur.

Table 5 reports all four measures of welfare change for each of the eleven countries for six pairwise comparisons involving benchmark, free trade, and autarky equilibria. In the first two rows the CV is the compensating income variation and EV is the equivalent income variation. The next two rows of Table 5 report the MCV (modified money metric compensating variation) and MEV (modified money metric equivalent variation) measures of welfare change. We regard the MCV and MEV measures as more reliable measures of welfare change than the CV and EV since they adjust for trade imbalance changes.

Table 5 Pairwise Welfare Comparisons (by Country) between Benchmark, Free Trade and Autarky Equilibria for All Countries (Compensating Variation, Equivalent Variation, Money Metric Measure Gains from Trade Component)

Country	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Moving from Benchmark Equilibrium for the World Economy to Free Trade Equilibrium for the World Economy											
CV	987.838	2,738.744	188.484	-748.148	-2,173.259	-277.998	2,388.160	3,667.214	-1,397.359	-19,645.813	19,189.310
EV	1,018.917	2,610.277	186.573	-745.143	-2,126.092	-295.450	2,990.431	3,589.242	-1,383.254	-19,629.836	18,495.481
MCV	987.838	2,738.744	188.484	-748.148	-2,173.259	-277.998	2,388.160	3,667.214	-1,397.359	-19,645.813	19,189.310
MEV	1,018.917	2,610.277	186.573	-745.143	-2,126.092	-295.450	2,990.431	3,589.242	-1,383.254	-19,629.836	18,495.481
Moving from Free Trade Equilibrium for the World Economy to Benchmark Equilibrium for the World Economy											
CV	-1,018.917	-2,610.277	-186.573	745.143	2,126.092	295.450	-2,990.431	-3,589.242	1,383.254	19,629.836	-18,495.481
EV	-987.838	-2,738.744	-188.484	748.148	2,173.259	277.998	-2,388.160	-3,667.214	1,397.359	19,645.813	-19,189.310
MCV	-1,018.917	-2,610.277	-186.573	745.143	2,126.092	295.450	-2,990.431	-3,589.242	1,383.254	19,629.836	-18,495.481
MEV	-987.838	-2,738.744	-188.484	748.148	2,173.259	277.998	-2,388.160	-3,667.214	1,397.359	19,645.813	-19,189.310
Moving from Benchmark Equilibrium for the World Economy to Autarky Equilibria for Individual Economies											
CV	-22,173.830	16,832.330	43,752.635	2,461.023	38,520.104	-14,712.716	-7,508.520	2,091.008	-55,093.789	-419,305.750	105,828.763
EV	-20,918.914	20,587.667	47,853.423	2,612.154	50,168.899	-12,473.452	-5,501.803	3,142.329	-56,052.700	-411,149.576	138,047.408
MCV	-9,977.113	-6,978.836	-30,213.049	-12,337.686	-62,427.007	-38,279.634	-9,948.688	-23,954.545	-2,018.865	-28,180.668	-85,061.692
MEV	-8,722.091	-3,223.577	-26,112.634	-12,186.571	-50,778.934	-36,040.127	-7,941.961	-22,903.258	-2,977.733	-19,953.665	-52,844.020
Moving from Autarky Equilibria for Individual Economies to Benchmark Equilibrium for the World Economy											
CV	20,918.914	-20,587.667	-47,853.423	-2,612.154	-50,168.899	12,473.452	5,501.803	-3,142.329	56,052.700	411,149.576	-138,047.408
EV	22,173.830	-16,832.330	-43,752.635	-2,461.023	-38,520.104	14,712.716	7,508.520	-2,091.008	55,093.789	419,305.750	-105,828.763
MCV	8,722.091	3,223.577	26,112.634	12,186.571	50,778.934	36,040.127	7,941.961	22,903.258	2,977.733	19,953.665	52,844.020
MEV	9,977.113	6,978.836	30,213.049	12,337.686	62,427.007	38,279.634	9,948.688	23,954.545	2,018.865	28,180.668	85,061.692
Moving from Free Trade Equilibrium for the World Economy to Autarky Equilibria for Individual Economies											
CV	-23,253.871	14,698.186	43,582.051	3,163.055	40,152.536	-14,364.227	-11,589.675	-297.390	-53,734.198	-399,286.507	91,649.911
EV	-21,268.694	18,862.162	48,155.065	3,370.836	53,455.132	-11,458.693	-6,781.903	-456.622	-55,226.912	-391,838.405	124,036.734
MCV	-11,057.162	-9,112.986	-30,383.618	-11,635.647	-60,794.526	-37,931.132	-14,029.848	-26,342.979	-659.287	-8,158.142	-99,240.640
MEV	-9,071.872	-4,949.076	-25,810.972	-11,427.885	-47,492.674	-35,025.363	-9,222.060	-26,502.203	-2,151.956	-642.573	-66,854.644
Moving from Autarky Equilibria for Individual Economies to Free Trade Equilibrium for the World Economy											
CV	21,268.694	-18,862.162	-48,155.065	-3,370.836	-53,455.132	11,458.693	6,781.903	456.622	55,226.912	391,838.405	-124,036.734
EV	23,253.871	-14,698.186	-43,582.051	-3,163.055	-40,152.536	14,364.227	11,589.675	297.390	53,734.198	399,286.507	-91,649.911
MCV	9,071.872	4,949.076	25,810.972	11,427.885	47,492.674	35,025.363	9,222.060	26,502.203	2,151.956	642.573	66,854.644
MEV	11,057.162	9,112.986	30,383.618	11,635.647	60,794.526	37,931.132	14,029.848	26,342.979	659.287	8,158.142	99,240.640

We first consider comparisons between free trade and benchmark equilibria. Looking at the first row of Table 5 [5] for Germany, for example, we see that $CV = MCV =$ \$188.484 and $EV = MEV =$ \$186.573 [6]. Both of these measures imply that Germany's welfare increases moving from the benchmark equilibrium to free trade. If they are negative, as the case for Italy, it means that moving from the benchmark equilibrium to free trade reduces welfare. One can see from Table 5 that Australia, Canada, Germany, Mexico and Norway benefit from a move from the benchmark equilibrium to free trade while Italy, Japan, Korea, UK and the US lose.

Moving from the benchmark equilibrium to free trade in Table 4 the relative price of non-manufactured goods rises by around 7.6%. Most countries who benefit moving to free trade are net exporters of non-manufactured goods while losers are importers of manufactured goods. The exceptions are Germany and the UK. In the case of the UK, at the benchmark equilibrium they are net exporters of non-manufactured goods but they export a small amount. For Germany, they are net importers of non-manufactured goods and their welfare rises in a move to free trade. The welfare results can be explained, for the most part, by the terms of trade effects of moving from the benchmark equilibrium to free trade.

Comparing autarky to free trade requires making use of the modified money metric measures of welfare change. Looking at the first two rows of the last box of Table 5 we see that using an CV or EV, Canada, Germany, Italy and Japan lose moving from autarky to free trade. This result is explained by examining the last row of Table 3. Here we see that all of these countries have trade surpluses. At autarky there can be no trade deficit or surplus, but for these four countries trade surpluses arise at free trade. The CV and EV measures do not count the trade surplus as part of consumption and hence the trade surplus does not factor into free trade welfare. Thus, autarky appears to lead to higher welfare than free trade because the free trade calculations ignore the trade surpluses. This is confirmed by looking at the MCV and MEV measures. For these measures the trade surpluses are included in the welfare calculations at free trade and one can see from the last two rows of Table 5 that once this is done all countries benefit in the move from autarky to free trade.

Further confirmation of this interpretation can be seen by considering the United States. Table 3 confirms that the U.S. has a large trade deficit. The CV and EV calculations only consider consumption and ignore the large trade deficit. However, the trade deficit implies the existence of some future liability that the welfare calculations ignore. Once we account for these deficits in the MCV and MEV measures we see that the gain from moving from autarky to free trade falls from almost \$400 billion under the EV measure to about \$8 billion under MEV. These results confirm that the money metric measures are the appropriate ones for welfare comparisons.

[5] All entries in Table 5 are in U.S. dollars.

[6] Note that if we look at the first four rows of Table 5 one can see that $CV = MCV$ and $EV = MCV$. The reason that these measures don't change is that in both the benchmark and free trade equilibria the measures are adjusted to reflect trade imbalances so the *comparison* between them does not change. As we will see when comparing autarky (there can be no deficit or surplus at autarky) to either the benchmark equilibrium or free trade the money metric measures give you very different results than the measures that ignore the trade imbalances.

• Winners and Losers

So, who wins and who loses from Globalization? There are several ways to answer that question. First, we might ask who benefits from the status quo? That is, who gains moving from autarky to the benchmark equilibrium? Using benchmark income from Table 4 we compute the modified welfare gain as a the percentage of income countries receive moving from autarky to the benchmark equilibrium. The results are displayed in Table 6. What we see is that all countries gain in the move from autarky to the benchmark equilibrium. Norway and Korea are the big winners in the move from autarky to the benchmark while countries like the US and the UK gain relatively little in percentage terms; smaller countries gain more than larger ones.

In the Korean case structure of production in autarky is heavily in favour of manufacturing. In this case, increasing consumption of manufacturing by money along the domestic production frontier occurs in a region of the frontier which has sharper curvature and so it is costly to adjust to the consumption bundle in autarky implied by domestic preferences with no trade. This is reflected in the sharp rise in the relative price of non-manufacturing goods in autarky. This effect operates in the opposite direction and is even more pronounced in the Norwayan case. Here benchmark production is heavily of the non-manufactural good and adjusting consumption in favour of more manufacturing in autarky involves again adjustment along a portion of the domestic frontier with sharp curvature. There is a sharp fall in the relative price of non-manufactures to manufactures, and a large adjustment in consumption. Very large gains thus occur in moving from autarky to the benchmark equilibrium in the Norwayian case.

Table 6 Welfare Gains Obtained Moving from Benchmark Equilibrium to Free Trade and from Autarky to Benchmark Equilibrium

Country	Welfare Gains Obtained as a % of GDP	
	from Benchmark Equilibrium to Free Trade	from Autarky to Benchmark Equilibrium
Australia	1.13310	13.64046
Canada	1.57348	4.57758
Germany	0.05328	8.30243
Italy	- 0.32978	5.72884
Japan	- 0.20781	7.57468
Korea	- 0.19180	22.92523
Mexico	2.17538	5.52408
Norway	11.56845	105.35620
UK	- 0.40692	0.72354
US	- 0.89305	1.54638
ROW	1.37307	7.47249

Table 6 also displays the welfare gains obtained moving from the benchmark equilibrium to free trade. Here the results are mixed. Australia, Canada, Germany, Mexico, Norway and the ROW all benefit from a move from the benchmark equilibrium to free trade. Italy, Japan, Korea, UK and the US all lose in the move to free trade. This shows there are winners and losers in moving from the status quo to free trade.

The other striking finding is that the gains moving from autarky to the benchmark equilibrium are much larger than the gains moving from the benchmark equilibrium to free trade. This suggests that the world has already reaped most of the benefits to trade liberalization. Or, put another way these welfare results suggest that the world is already highly globalized if we measure the extent of globalization in terms of how completely the gains from trade are exploited by the global economy. So, while these results suggest that the additional welfare gains from trade liberalization are rather modest they also imply that the risks from increasing protection are large. That is, were the world to move substantially in the direction of autarky the welfare losses would be large.

We next look at prices and trade volumes to see if these results are consistent with the conclusion that the world is highly globalized.

4.2 Results on Prices and Quantity Measures of Distance

Table 7 reports distance measures between autarky, benchmark and free trade equilibria, both for the world economy and for individual economies. These measures are similar to those obtained in Riezman, Whalley and Zhang (2004) [7] for individual economies considered as separate price taking economies, not part of an intergated global model. The measures differ sharply from each other and highlight some of the difficulties involved in choice of measure. Consider the first set of measures in Table 7. These measure the distance between the benchmark equilibrium and free trade for the global economy. One can see that the measures vary from 0.12 for prices to 9.39 for exports. This suggests, a small distance between observed and free trade equilibria in prices, but a large distance in exports. So, the apparent extent of globalization differs depending on whether one looks at prices or quantities. The two excess demand measures for the global economy are similar, but the Debreu shrinkage measures though small differ in sign.

[7] This paper can be downloaded at: http://www.biz.uiowa.edu/faculty/rriezman/index.html

Table 7 Distance Measures between Benchmark and Free Trade Equilibria for the both World Economy and Individual Economies

Table 7.1 Distance Measures between Benchmark and Free Trade Equilibria for the Global Economy

- Euclidean Distance Measures $M_{P_0} = 0.117849$ and $M_Q = 2.458791$ and $M_X = 9.390356$
- Excess Demand Measures $R_G^1 = 0.219311$ and $R_G^2 = 0.245125$
- Debreu Type Shrinkage Measures $R_S^1 = -0.000564$ and $R_S^2 = 0.000582$

Table 7.2 Distance Measures between Benchmark and Free Trade Equilibria for Individual Country Economies

Metrics	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Euclidean Distance Measures											
M_w	0.041843	0.042762	0.030818	0.029813	0.032157	0.026181	0.188594	0.010081	0.004707	0.000517	0.037282
M_P	0.133772	0.117849	0.101723	0.101723	0.056581	0.258159	0.333813	0.112828	0.113056	0.003313	0.117849
M_Q	1.612316	1.705527	4.509718	1.385504	2.900502	0.823852	2.930633	0.424936	1.838091	0.432600	8.483021
M_L	1.750672	1.729516	4.807012	1.476850	3.058689	0.903682	3.632118	0.441523	1.928243	0.462946	8.625298
M_X	3.841793	4.304862	8.487088	6.822048	14.465406	10.987427	7.040247	3.365887	6.120471	15.587995	22.270695
Excess Demand Measures											
R_G^1	0.509648	0.186235	0.412197	0.237774	0.243526	0.545118	0.247395	1.416780	0.185798	0.179307	0.134739
R_G^2	0.524335	0.143535	0.521915	0.338454	0.299146	0.719123	0.335536	1.451943	0.177848	0.185997	0.141714
Debreu Shrinkage Measures											
R_S^1	-0.030766	-0.031124	0.004469	0.013476	0.006693	0.036958	-0.050930	-0.247514	0.008215	0.019407	-0.021678
R_S^2	0.031180	0.031428	-0.004142	-0.013091	-0.006556	-0.035038	0.053606	0.270046	-0.008113	-0.019075	0.021870

Table 7.3 Distance Measures between Benchmark and Autarky Equilibria for all Country Economies

Metrics	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Euclidean Distance Measures											
M_w	0.174374	0.147507	0.153328	0.155202	0.288625	0.192195	0.382744	0.069983	0.006582	0.012734	0.218430
M_P	0.522312	0.412579	0.543154	0.539782	0.514341	1.974109	0.661501	0.875036	0.155334	0.082241	0.699221
M_Q	6.046597	7.617513	41.152951	8.896355	39.994217	7.646540	4.104048	6.164962	2.607488	10.651933	73.284092
M_L	5.176819	7.021182	49.020056	10.546048	47.854526	9.683405	3.886191	3.557482	2.540845	11.538126	58.835452
M_X	24.157752	18.022095	77.250751	31.636240	154.216464	49.979224	13.933796	29.708657	51.865558	327.082620	121.992460
Excess Demand Measures											
R_G^1	0.152857	0.185080	0.266700	0.077437	0.143105	0.187395	0.017917		0.164474	0.183230	0.201450
R_G^2	0.446124	0.191828	0.278201	0.230011	0.185377	0.507246	0.206255	1.048410	0.061986	0.025217	0.191574
Debreu Shrinkage Measures											
R_S^1	-0.200194	0.002560	-0.017892	-0.060966	-0.066650	0.551173	-0.046446	0.542333	-0.029982	-0.397173	-0.110640
R_S^2	-0.273794	-0.044330	-0.082874	-0.093735	-0.082629	-0.524403	-0.209398		-0.033514	-0.263118	-0.290318

Table 7.4 Distance Measures between Free Trade and Autarky Equilibria for all Country Economies

Metrics	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Euclidean Distance Measures											
M_w	0.216224	0.190224	0.184137	0.185099	0.320853	0.218360	0.571341	0.080045	0.011290	0.012395	0.255611
M_P	0.656086	0.530384	0.644891	0.641372	0.570840	2.232334	0.995317	0.987861	0.268389	0.079159	0.816999
M_Q	7.627822	9.314928	45.599368	10.265264	42.844956	8.431174	6.990254	6.557884	4.442764	10.219381	81.604115
M_L	6.927491	8.750698	53.827068	12.022898	50.913215	10.587087	7.518309	3.999004	4.469088	11.075180	67.460751
M_X	27.889169	18.541307	84.682848	38.408869	168.242405	60.849098	20.854285	30.463291	55.603348	311.494872	112.563328
Excess Demand Measures											
R_G^1	0.142919	0.185080	0.255105	0.073794	0.139600	0.164328	0.013735		0.159816	0.176702	0.201450
R_G^2	0.564634	0.235754	0.306446	0.265111	0.197756	0.566934	0.384011	1.100731	0.106905	0.024199	0.217967
Debreu Shrinkage Measures											
R_S^1	-0.274995	-0.092989	-0.016024	-0.164896	-0.092967	0.502495	-0.048597	0.362027	-0.041422	-0.238986	-0.065662
R_S^2	-0.323047	-0.103885	-0.139968	-0.143497	-0.114597	-0.513885	-0.346322		-0.094941	-0.288492	-0.240493

Table 7 also contains three tables that compute distance measures for each country for each of our three comparisons. These measures differ sharply across countries, and these in turn depart from those for the global economy. In addition, as in the case of the measures for the global economy, different measures paint a different picture of the extent of globalization.

Of interest here is Table 8 which reports normalized Euclidean distance measures for comparisons between benchmark, free trade, and autarky equilibria. We normalize the distance between autarky and free trade to be one and then ask how close the benchmark equilibrium is to those two equilibria. Then, for each distance measure we can determine how close the measures are to the autarky value and the free trade value. Consider the distance measure for wages, M_w. According to Table 8 for Australia the benchmark wage rate is 80% of the way towards the free trade wage from autarky. For Canada the benchmark quantity measure is 82% of the way from autarky towards free trade. We have computed averages for each of the distance measures and looking at the averages for each measure we can say that according to these the world appears to be about 80% of the way to complete globalization from autarky.

Which measures to use, and how to interpret such measures when calculated is not always clear. Not only do they vary in size, they also vary in their percentage changes across barrier reductions of different depth. Measures will also vary further with the degree of disaggregation in models, the structural form of models, and the treatment of factor flows and barriers.

Table 8 Normalized Euclidean Distance Measures in Comparisons among Benchmark, Free Trade, and Autarky Equilibria

Metrics	Australia	Canada	Germany	Italy	Japan	Korea	Mexico	Norway	UK	US	ROW
Free Trade and Autarky Equilibria											
M_w	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
M_P	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
M_Q	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
M_L	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
M_X	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Benchmark and Free Trade Equilibria											
M_w	0.193517	0.224798	0.167365	0.161065	0.100223	0.119898	0.330090	0.125942	0.416918	0.041710	0.145854
M_P	0.203894	0.222196	0.157737	0.158602	0.099119	0.115645	0.335384	0.114214	0.421239	0.041852	0.144246
M_Q	0.211373	0.183096	0.098899	0.134970	0.067698	0.097715	0.419246	0.064798	0.413727	0.042331	0.103953
M_L	0.252714	0.197643	0.089305	0.122836	0.060077	0.085357	0.483103	0.110408	0.431462	0.041800	0.127857
M_X	0.137752	0.232177	0.100222	0.177616	0.085980	0.180568	0.337592	0.110490	0.110074	0.050043	0.197850
Benchmark and Autarky Equilibria											
M_w	0.806451	0.775438	0.832684	0.838481	0.899555	0.880175	0.669905	0.874296	0.582994	1.027350	0.854541
M_P	0.796103	0.777887	0.842242	0.841605	0.901025	0.884325	0.664613	0.885789	0.578764	1.038934	0.855841
M_Q	0.792703	0.817775	0.902490	0.866646	0.933464	0.906937	0.587110	0.940084	0.586907	1.042327	0.898044
M_L	0.747286	0.802357	0.910695	0.877164	0.939923	0.914643	0.516897	0.889592	0.568538	1.041800	0.872143
M_X	0.866206	0.971997	0.912236	0.823670	0.916633	0.821363	0.668150	0.975228	0.932778	1.050042	1.083767

5 Concluding Remarks

This paper reports metrics of distance between observed, free trade and autarky equilibria both for the world economy and for individual economies. These are constructed as distance measures between barrier restricted and globally integrated or country segmented equilibria. Literature on equilibrium metrics in general is limited, and our paper is a contribution to part of a potentially wider discussion of metrics of distance across equilibria in other circumstances.

We report measures generated using a global model involving 10 OECD countries and residual rest of world using 2000 data applied to relatively simple 2 good country models. These suggest both substantial differences in measures for the global economy and differences across countries in country measures for the same degree of globalization. Measures suggest that large economies integrating with small economies experience little relative price change and hence are already integrated into the global economy (their own). Small economies measures of integration are influenced as much if not more by foreign barriers as their own.

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