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The Income Elasticity of Trade: Theory, Evidence, and Implications

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Abstract

The theoretical idealization inherent in the application of unitary income elasticities of trade may distort the results of trade policy experiments. This will be the case whenever such a maintained hypothesis is not supportable by recent experience. Alternative modeling specifications, e.g., flexible functional forms with constraints, may be employed to overcome deficiencies in policy model results which are imposed by an assumption of homotheticity. Econometric and numerical estimates of income elasticities of trade provide a rich harvest of new information for use in trade policy modeling.

Summary

The income elasticity of trade is defined as the percentage change in trade, either for exports or for imports, with respect to a percentage change in income. The income elasticity of trade can be defined either in aggregate terms or in terms of individual commodities and either for a single country, a region, or for the entire world. For example, the aggregate global income elasticity of trade (AGIET) would be defined as the percentage change in world imports (or exports), attributable to a percentage change in world income (or output), *ceteris paribus*. Between 1960 and 1995, a gross measure of the average annual AGIET is 1.61.[1] It measures all factors affecting the expansion of trade, including reductions in transactions costs, increased trade liberalization, influences of economies of scale due to globalization, and general growth in world income. Existing simulation models of trade often concentrate on identifying the impacts of trade liberalization, but giving little attention to any of the other factors that affect the expansion of trade. For example, because of theoretical reasons and for simplicity of calculation, contemporary trade models rely on the maintained hypothesis of homotheticity in demand, i.e., on unitary income elasticities of trade--see Pogany (1997). By assuming constant transportation costs, constant returns to scale, and homothetic preferences for demands, these models necessarily assign a value of unity to the aggregate global income elasticity of trade. These assumptions in contemporary trade policy models cannot be supported by the recent historical experience, and the use of an appropriate measure of the AGIET would offer considerable advantages.

Linear homogeneity provides a framework for assuring steady state solutions in models. Nonetheless, there are alternative solutions with which to reconcile, at least to some extent, fundamental

[1] The 1997 *Economic Report of the President* reports that from 1960 to 1995 world exports, measured in real terms, i.e., 1995 dollars, grew at an annual average rate of 6.1 percent per year while world output grew at 3.8 percent--see p. 243. These rates of growth imply that world wide the income elasticity of trade is 1.61.

numerical and theoretical requirements for computation of model realizations that would provide more realistic simulations for use in trade policy analysis.

The paper demonstrates the prevalence of nonhomotheticity in postwar trade; refers to econometric estimates the AGIET; illustrates the usefulness of the AGIET, offers ideas about identifying its future levels; and mentions some solutions in the modeling literature that provide homogeneity in the limit while allowing a greater appreciation of reality in the realization of the process.

Introduction

A recently completed USITC study, *The Dynamic Effects of Trade Liberalization: An Empirical Analysis* (332-375), describes some of the reasons for adherence to homotheticity in trade models, demonstrated the importance of calculating the AGIET, and introduced estimates of this measure. This present paper reports the results of research conducted in conjunction with that study. It extends the analysis of this measure to derive the growth and welfare effects of trade policies; to analyze trade liberalization as a policy alternative; and, to calculate and analyze trade elasticities.

Theory versus Evidence

As elaborated in the cited study, an understandable, but misguided controversy exists between the numerical requirements for handling aggregate global income (GDP) in dynamic trade models and the findings of econometric inquiry. To recapitulate the issue, dynamic trade models usually assume homothetic consumer preferences (that is, unitary income elasticities of demand for trade), an assumption that guarantees long-run equilibrium solutions. In such models, an income elasticity of demand for imports in excess of unity, meaning that imports grow faster than income, would eventually eliminate domestic production over the long run. Similarly, an income elasticity smaller than unity implies an ever shrinking proportion of imports in income, leading to an eventual elimination of trade. While this is a cogent argument for the use of unitary income elasticity, the assumption is not supported by experience with respect to the growth of trade since World War II both in absolute terms and relative to income.

A prominent trade-related phenomena of the postwar era has been the shift of trade from interindustry type of exchanges (such as machines for raw materials) to intraindustry trade (that is, trade in near substitutes, such as in different makes of automobiles), and the considerably faster growth of trade than income.[2] Unitary income elasticities (reflecting homothetic preferences) proscribe any change in the ratio of imports to income. And, therefore such homothetic models are unable to replicate the historical

[2] For descriptions of interindustry and intraindustry trade, see Markusen et al. (1995).

increase observed in the relative importance of trade when these models are used in backcasting experiments. The postwar evidence is not consonant with the model structures.

Consumption theory suggests that, on average, individuals with higher incomes, because they have a greater amount of discretionary income, may exercise more choice in the variety of products and services consumed. The higher income consumers might be categorized as being "choosier" than those who are less well off. Extrapolating this hypothesis, the wealthier a nation is the more its population is able to, and indeed wants to, choose from among an increased variety of food items, clothing, durable goods, and personal services. Furthermore, trade theory recognizes the availability of greater variety in products and services as a gain from international trade. Consumer desire for greater variety may partially explain movements from interindustry trade to intraindustry trade. Rising incomes, particularly in the developed countries, appear to have played a significant role in the postwar development of intraindustry trade. Trade in near-substitute consumer products is a sign of growing consumer preoccupation with variety, a phenomenon that both consumer theory and international trade theory attribute to higher income levels.[3] Moreover, since the growth of intraindustry trade was the primary component of the rapid growth of trade during the past decades, the growth in income likely played a role in causing trade to grow faster than itself. In other words, income levels played an active role in causing trade to increase faster than output.

Consequently, the rise in incomes has been one cause for the increase in trade, and is as evidenced, nonhomothetic, rather than homothetic demand characterized world trade during the past decades.[4] The consistently faster growth of trade than income and the structural change in trade during the postwar era

[3] Technological similarities and overlaps in the production of near-substitute consumer products have engendered trade in near-substitute inputs. Some of the fastest growth in world trade is in near-substitute inputs. See USITC (1997).

[4] See Pogany (1996) for a discussion how the Almost Ideal Demand System may provide for some degree of nonhomotheticity in general equilibrium modeling.

represents *prima facie* evidence that trade-expanding nonhomotheticity prevailed during the epoch. The AGIET had to be in excess of unity, rather than being equal to it.[5]

The "new international trade theory" that explains the faster growth of trade than income and the emerging prominence of intraindustry trade during the past decades provides a justification for assuming nonhomotheticity. This aspect of the new international trade theory was put into focus by J.R. Markusen who demonstrated that the nonhomothetic demand has been a salient characteristic of postwar economic development and trade (Markusen (1986)).[6]

This insight should be reflected in the structure of models being used to simulate consequences of trade liberalization. However, its practical application necessitates estimates of the AGIET.

Estimation

The value of the AGIET can be derived directly from global income and trade data, and it may be inferred from aggregating estimates of national income elasticities. This latter procedure begins with estimating the national income elasticities to import for selected countries. The literature is rich in econometric estimates of income elasticities, offering guidance for such endeavors in the choice of structure, functional form, and data, as well as in the interpretation of results.[7]

The difficulty with this approach is that estimations for most developing countries produce elasticity values that are unconvincing. In connection with USITC (1997), the staff analyzed data for

[5] Establishing this relationship is important in the interpretation of econometric results.

[6] For a summary of the Markusen article, showing that the world aggregate global income elasticity in excess of 1 underlies the postwar era trade experience, see USITC (1997).

[7] For a survey of these studies until the mid-1980s, see Goldstein and Khan (1985). It is apparent from these studies that it is possible to construct different AGIETs from individual country estimates, according to whether the export response is measured to foreign income (income elasticity to export) or the import response is measured to domestic income (income elasticity to import). However, calculations for the world must converge over a sufficiently long period.

several developing countries (trying both the single country and systems approaches) with but limited results.[8]

Consequently, the calculation of the AGIET has to rely primarily on estimates made for the industrialized countries, meaning the 24 original members of the OECD--these countries account for the bulk of world trade. For the rest of the world, calculations for some of the countries included in the group were used as a guide to establish a range of conjectures to be made.[9] The following formula was applied:

(2) $$\sum_j w_j e_j + \left(1 - \sum_j w_j\right) e_Z = e_W$$

where w_j = the weight of the k^{th} country in world imports,
ϵ_j = estimated aggregate income elasticity of import demand for country "j",
ϵ_Z = a constant for aggregate income elasticity of import demand for countries not estimated, and
ϵ_W = AGIET

[8] Even various dummy formulations to account for such episodes of nonmarket influences did not improve the results for most of the developing countries included in the analysis. Indeed, most studies that may be found in the literature report on calculations performed for the industrialized countries. (See Goldstein and Khan (1995)). A notable exception was the study prepared by L.C. Hunter and J.R. Markusen in 1988. Using the linear expenditure system, these authors included some developing countries in their calculations, (Hunter and Markusen (1988)).

[9] The following are examples of what are viewed to be successful regression results, generating income elasticities to import for countries not included among the original 24 OECD members: For the period 1970-1993; Argentina, 2.41; Columbia, 2.08; and Zimbabwe, 1.23. For the period 1965-1993; Thailand, 1.40. All these elasticities were significantly different from 1 at least at the 10 percent level of significance. The 1.37 income elasticity calculated for Hungary (1982-1993) and the 0.86 calculated for Poland (1965-1993) while statistically significant these values were not significantly different from 1.

Import demand equations for a nation that feature the customary restrictions of consumer optimization and imperfect substitutability between domestic and imported products use the ratio of import prices to domestic prices to capture the substitution effect:

(3) $$log\, M_j = b_j + e_{Yj}\, log\, Y_j + e_{Pj}\, log \left(\frac{P_{Dj}}{P_{Mj}} \right) + m_j$$

where ϵ_{Yj} = aggregate global income elasticity with optimizing behavior, and

ϵ_{Pj} = elasticity with regard to the price ratio of domestically sold and imported products and services.[10]

Equation (3) estimates appear in USITC (1997).

The value of the AGIET depends on the estimates obtained for ϵ_{Yj} and on the alternative values assigned to ϵ_Z. These alternative values may be limited by lower and upper bounds, allowing for the examination of various hypotheses about the value of the estimated AGIET. Zero may be considered an absolute lower bound, since negative numbers would render trade goods inferior products.[11] And, for the sake of exposition, the average aggregate global income elasticity obtained for the industrialized countries may be considered an upper bound. An average between these point then might be construed as representing the "expected value" of the aggregate global income elasticity in the context of a given estimation exercise, and unitary aggregate global income elasticity could be considered the conventional. A combination of lower estimates obtained econometrically for ϵ_{Yj} and the lower-bound (L) assumption for ϵ_L may be used to form a lower-bound estimate for ϵ_W. Similarly, the higher estimates for ϵ_{Yj} combined with the upper-bound assumption for ϵ_U may be used to construct an upper-bound for ϵ_W.

[10] The specification is derived from the conditions of optimizing consumer behavior, which specify that the domestic and import price elasticity of import demand sum to zero. This requirement follows from the compensated (Hicksian) nature of the price elasticities in the model. In this formulation, the level of real income during each period is the budget constraint, subject to which domestic and imported goods are substituted for one another. See Deaton and Muellbauer (1986).

[11] There is no country for which aggregate import demand would consist solely of rice, wheat flour, or potatoes.

Intermediary boundaries for ranges may be established between the lower and upper bounds as they are defined above, and these provided labels for discursive purposes. For example, an AGIET value between 1.01 and 1.20 may be labeled as "moderate;" between 1.21 and 1.50 may be labeled "strong;" and above 1.50 may be labeled "very strong." For the 1965-1993 epoch, the USITC study found the ϵ_w to be in excess of 1.5.

Applications

Establishing the values for the AGIET may give implications as to the aggregate global income elasticity for domestically produced goods and thereby provide insights. Specifically, expenditures of aggregate domestic income (Y) may be divided between domestic goods (D) and foreign goods (T), and Engle curves can be constructed which trace the utility frontiers between those domestic and foreign products. Thus:

(4) $$Y \equiv D + T$$

Any changes in the relative prices of domestic and imported goods will exert substitution and income effects on the quantities demanded of those goods. This suggests the existence of a virtuous circle between efficiency gains from trade, i.e., reduction in the price of imported goods, and increases in real income that are induced. Thus, there exists an interaction between world economic growth and the growth of international trade; this interaction is a continuous and reciprocal process. If formalized, this process becomes a dynamic model, since increases in domestic income generates increases in trade, increases in trade will increase efficiency, increased efficiency reduces prices, reduced prices result in increases of real income which then further increase trade. In such a model, trade and income mutually determine one another within the model over time. This is the context in which information about the AGIET is of critical importance in trade policy analysis. It allows for a more complete assessment of economic growth and welfare effects of trade liberalization and it reveals more fully the efficacy of trade liberalization as an economic policy tool. The numerical demonstration of this is based on comparisons between growth under

an estimated AGIET and the homothetic assumption. Finally, as it will be shown, information about the value of the AGIET may help calculate and analyze trade elasticities.

Growth and Welfare Implications

This section numerically demonstrates that an application of an AGIET different from unity (one that has been derived from the historical data) has a significant impact on assessments of economic growth and will provide welfare-enhancing impacts of trade liberalization over such realistic long-term forecast periods as 10 or 20 years. The procedure compares the patterns of income growth and welfare accumulation under the homothetic and nonhomothetic assumptions over the period 1980-1993.[12]

During the period 1960-1995, world real economic growth averaged 3.8 percent and the real growth of world trade averaged 6.1 percent.[13] Based on the distribution of 20 percent trade and 80 percent production for domestic use that prevailed in the world economy during 1980-1993, the following numerical correspondence may be established:

$$(1.038 \cdot Y) = (1.032 \cdot D) + (1.061 \cdot T)$$

where Y is the world real GDP, D are domestic goods and T (either imports, M, or exports, X) are trade goods. If econometric estimate of the AGIET of 1.50[14] is used for 1960-1995, the contribution of income and substitution effects may be calculated:

$$(1.038 \cdot Y) = (1.032 \cdot D) + (1.013 \cdot 1.059 \cdot T)$$

[12] The cut-off date of 1993 was chosen, because that was the last year in the time series used to calculate the national income elasticities, based upon which the AGIET had been estimated.

[13] Calculations were based on the same data that had been used to generate national income elasticities.

[14] The 1.50 AGIET is an econometric estimate for the period 1980 to 1993 as reported in the USITC (1997).

where, 1.013 indicates the contribution of the income effect to the growth of income, and 1.059 indicates the contribution of the substitution effect to the growth of income during the period.[15] In models, based on the homothetic demand system, 1 would enter in the place of 1.013, resulting in an annual growth rate of 3.5 percent, instead of the observed 3.8 percent. The following tabulation compares the actual economic growth (growth factors) for 10 and 20 years with those calculated under the homothetic assumption for the same period:

Model	Annual growth rate	10-year compound growth	20-year compound growth
nonhomothetic	3.8	50.7	118.8
homothetic	3.5	46.0	105.9

Where the homothetic model would predict a 46.0 percent growth for 10 years, the nonhomothetic model would predict a growth of 50.7 percent over the same period. The interpretation for the 20-year period is analogous. Consequently, a dynamic forecasting model using the homothetic approach would have shown a minimum of 10.3 percent less gain in world output between 1980 and 1990. If the 3.8 percent growth rate that prevailed continued through the current decade, the extent of understatement would have been a minimum of 12.2 percent. If part of the growth in world trade had been attributed to the effects of the Tokyo Round, the understatement of the output-enhancing potential of trade liberalization would have been proportional. Since welfare effects are usually based on the growth of income, these underestimations would be carried over into their assessments.

[15] In this example, the simple ratio between trade and income growth is 6.1: 3.8 = 1.61. Thus, given the estimated AGIET of 1.50, the substitution effect is 1.07. That is, $1.50 \cdot 1.07 = 1.61$. The percentage distribution between the income and substitution effects is 0.584 and 0.416. Hence, if the increase in trade as a result of increase in income is "$\triangle Y$" and the increase in trade as a result of price differentials is "$\triangle P$," the relationship between these two values is $\triangle P = 0.71 \triangle Y$. Substituting this into $1.061 = (1 + \triangle Y)(1 + \triangle P)$ results in a quadratic expression: $0.71 (\triangle Y)^2 + 1.71 \triangle Y - 0.061 = 0$, which has one positive root: 0.0179. Thus, $\triangle P = 0.0127$.

The best available estimate for annual welfare gains arising from the Uruguay Round is approximately $270 billion (measured in 1991 prices) beginning in the year 2002.[16] Over a 10-year period this would mean $2.7 trillion. This estimate is based on the homothetic system. However, assuming an AGIET of 1.50, and a growth rate of 3.8 percent for 2002-2011, the continuously compounded welfare gains in 2002 would amount to $297.8 billion (that is, 10.3 percent more than under the homothetic assumption.). Over the 10-year period the gains would be roughly $3.0 trillion, rather than $2.7 trillion. Based on this calculation, worldwide trade liberalization would increase annual welfare gains by $30 billion more than estimated. Even if only one-fourth of the $30 billion ($7.5 billion) improves the welfare of the non-oil exporting developing countries, such improvement would approximately match the inflation-adjusted $7.4 billion U.S. international and humanitarian assistance envisaged for 2002.[17] That represents an underestimate of the expected benefits of the Uruguay Round which may occur, because of one particular standard simplification in contemporary trade models. That underestimate is on a level that is significant in the context of the current U.S. budget allocations for the purposes of international assistance.

Trade Liberalization Scenarios

Manipulating the $Y \equiv D + T$ relationship to reflect changes in each of the right-hand side variables equals the increment in world income, i.e., $\Delta Y \equiv \Delta D + \Delta T$. Algebraic manipulation of these identities results in the following expression, known as the Engel aggregation condition: $\epsilon_W w_T + \epsilon_D w_D = 1$, where ϵ_W is the AGIET, w_T is the share of trade in the world output, ϵ_D is the global aggregate income elasticity

[16] Harrison, Rutherford, and Tarr (1995).

[17] During 1990-1994, both the total exports and total imports of the non-oil exporting developing countries represented about one-fourth of world exports and imports, respectively. See, International Monetary Fund, *International Financial Statistics*, Washington, D.C., 1995. For planned U.S. budget allocations, see Executive Office of the President, Office of Management and Budget, *Budget of the United States Government, Fiscal Year 1998, Analytical Perspectives*, H. Doc. 105-003, vol. II.

to for domestic goods (AGIED) and w_D is the share of domestically sold goods in world output.[18] If $\epsilon_W > 1$, which was demonstrably the case in the postwar epoch, then $\epsilon_D < 1$.[19] Taking the dynamic effects of global trade on the growth of global income at their extreme, every dollar increase in trade is a dollar increase in total income. Hence, ϵ_T may be regarded as a measure of income expansion via trade. For example, $\epsilon_W = 1.50$ means that a $1.00 increase in income increases trade by $1.50, where T is counted as income in its entirety. Similarly, ϵ_D may be considered a measure of income expansion via production for domestic use. If $\epsilon_W = 1.50$, then $\epsilon_D = 0.90$, using the 20 percent - 80 percent distribution between trade and production for domestic use. This means that the same $1.00 increase in income increases domestic demand) by $0.90, where D is also counted as income in its entirety.[20]

This divergence in the strength of income growth via the two channels over a given time period is equivalent to asserting that the dynamic interaction between growth of income and growth of exports is greater than between growth of income and the growth of domestically produced and sold goods. Therefore, stimulating trade by removing obstacles to free trade contributes to the growth of combined world income more than stimulating production for domestic purposes exclusively, for example, by cutting domestic sales taxes. Under the conditions specified, dollar for dollar, trade liberalization also has a greater return on the loss in tax revenue, because increased growth through trade liberalization will generate more ratable activity than would production for domestic purposes.

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[18] The lower-bound of the AGIET is used to show the validity of the assertions under a conservative assumption.

[19] Since $w_T + w_D = 1$ and $\epsilon_W w_T + \epsilon_D (1 - w_T) = 1$ then ϵ_D can be expressed as $\epsilon_D = (1 - \epsilon_W w_T)/(1 - w_T)$. If $\epsilon_W > 1$, than $\epsilon_D < 1$. An increase in ϵ_W reduces ϵ_D. The value of ϵ_D approaches 1 as ϵ_W approaches 1. Thus, unitary AGIET means unitary AGIED. Together they mean a constant distribution of income between domestic use and trade.

[20] These numbers imply an acceleration in the growth of world real output after 1993. Data for 1994 and 1995, and predictions for 1997 and 1998 confirm this implication. See, International Monetary Fund, *World Economic Outlook*, Washington, D.C., May 1997.

This argument does not disparage the merits of stimulating economic growth through means other than trade liberalization. Domestic stimulus programs in well-functioning market economies are designed to raise output regardless its geographic destination. Moreover, the growth of exports is also expected to increase production for domestic purposes, and vice versa. The special significance of trade liberalization emerges in the current context of diminished possibilities to use conventional methods to raise aggregate demand. At present, the fiscal stimulation of national economies in the industrialized countries is limited by efforts to reduce budget deficits, and monetary stimulation is circumscribed by a host of domestic concerns and international cooperation to allow market forces to determine foreign exchange rates.[21] Under these circumstances, and as long as trade-expanding nonhomotheticity prevails, the removal of impediments to free trade is still a feasible way for the world community to engender global and national economic growth and to foster economic development.

Regional income elasticities to trade may also be calculated and used to assess the potential benefits of agreements. The difference between calculating income elasticity for a region, such as the Western Hemisphere or the APEC, and calculating it for the world is that, at the regional level, is that there is a balance of trade with the rest of the world.

Deriving Trade Elasticities

The AGIET can help screen out the substitution (price) effects from the simple ratio between trade and income growth. This, in turn, may help in the analysis of national estimates of income and price elasticities to import.[22]

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[21] For a description of constraints on economic policies in the industrial countries, see International Monetary Fund, *World Economic Outlook*, Washington, D.C., October, 1995 and May, 1997.

[22] Although the procedure described here refers only to imports, it is equally applicable to exports.

Procedure

The derivation is shown only for three geographic units (A, B, and C), which exhaustively subdivide the globe; however, the same algebra would apply for any number of units, that is regions or countries. Let the simple ratio between trade and income growth for the three units be denoted as G_A, G_B, and G_C, and let their respective weights in world imports be w_A, w_B, and w_C. Then the following inequality holds:

(5) $$G_A w_A + G_B w_B + G_C w_C > e_W$$

By using the ratio of the sum of the left-hand side of equation (5), denoted as G, to the right-hand side, as a scaling factor, equality can be imposed on equation (5). After scaling, that is dividing each term on the left-hand side by G/ϵ_W, G_j will be reduced to ϵ_j, that is, an estimate of the geographic unit's income elasticity to import, net of the price effect. With notations:

(6) $$e_A w_A + e_B w_B + e_C w_C = e_W$$

The assumption underlying this procedure is that the substitution effect is uniform across the geographic units. Although this is unlikely, major deviations from econometrically estimated income elasticities allow inference about the relative strength of substitution effects.

Numerical Illustration

Using four geographic units, the United States, Japan, Germany, and the rest of the world (ROW), equation (3) for the time period 1974-1993 may be written as follows:

$$(2.75) \cdot (0.146) + (1.23) \cdot (0.067) + (3.62) \cdot (0.093) + (1.32) \cdot (0.694) = 1.74 > \epsilon_W$$

United States + Japan + Germany + ROW = World

This means that the worldwide aggregate global income elasticity to trade had to be less than 1.74. Substituting 1.50 for the AGIET, the scaling factor becomes 1.16. This yields national income elasticities to import as follows: United States, 2.37; Japan, 1.06; Germany, 3.12; and the ROW, 1.14.

Calculations may be repeated for various levels of ϵ_w to gain more information about its magnitude in light of national income elasticity estimates found in the literature. Such calculations may also be used to test the hypothesis of the uniformity of the substitution effect. (In a two region world, the uniformity is perfect, since price ratios are mirror images.)

Future Levels of AGIET

Any dynamic trade model requires information about future levels of the AGIET. Therefore, some forecast of the AGIET, however cautious, is inevitable. Perhaps the most important general caveat that attends such an exercise is the suspected lack of ergodicity in AGIET time series.

A time series is called ergodic if its long-term average (for example, its 100-year average) would be of any help in estimating relatively short-term averages within the long-term period, as well as the averages during some future, relatively short-term periods.[23] Contemporary econometrics regards economic time series, such as annual observations of the AGIET for a 100-year period, as a single historical realization of the stochastic process that generated it. The implication is that under the same circumstances, the 100-year time series of AGIET might have been different from the actual one, and this view of economic data allows for a richer analysis of their distribution properties and periodicity--see Hamilton (1994). However, such a 100-year time series for AGIET is not readily available.

The study of the AGIET for the postwar period indicates that although such a time series is likely to fulfill the first condition of ergodicity, it does not fulfill the second condition. The long-term AGIET is likely to be stationary since the only number to which this long-term average could converge, that is, unity,

[23] For a time series to be ergodic, it must fulfill two requirements. It must be stationary (integrated to a zero degree or I[0]) and the stochastic process that generated it over time must have a "short memory." A stochastic process with a short memory means that the covariance between increasingly distant observations dissipate rapidly; equivalently, the observations far enough apart in time are independent from one another, that is, uncorrelated--see Hamilton (1994) for background information.

is unrealistic. In other words, any series showing a trend over time can be lengthened to the point when the trend may be disproved.

Concerning the second property of ergodicity, the long-term stochastic process that generates annual observations of the AGIET seems to have a long, rather than a short memory. National estimates that were generalized into the AGIET showed a remarkable stability in terms of range (USITC (1997)). Individual estimates may have varied, subject to the length of the sample period and the econometric technique, but, individually, they remained in the same ballpark. For the United States, for example, all estimates for the period 1965 to 1993 were above 1.50, indicating a very strong aggregate global income elasticity to import.

The lack of ergodicity is a favorable property in making short- to medium-term forecasts about the likely evolution of the AGIET. It means that if analysis found the AGIET to be in the very strong (over 1.50) range during the past 20 years, then, barring some unforeseen shock to world trade, is unlikely that it would fall below 1 during the next few years. Therefore, the temporal cohesion of annual observations between current and past values encourages the prediction that the same cohesion will prevail for some future period.

Indeed, tendencies in the world economy point to the continuation of above-unitary aggregate global income elasticity to trade. Calculations by the USITC staff showed that worldwide per capita gross real aggregate global income elasticity increased from 1.51 during 1986-1989 to 1.71 during 1990-1993. Worldwide per capita real income elasticities show significant increases in commodity categories that represent the leading sectors of world trade and comprise significant intraindustry components. Considerable increases in the worldwide per capita real income elasticities were observed in passenger cars, computers, and aircraft.

As mentioned earlier, the growth of per capita income was the underlying cause for the increased weight of intraindustry trade in total world trade since World War II. At present, trade in these sectors

dominates the exchanges among the high per capita, advanced industrialized countries. Higher incomes created both the demand for and the ability to supply variety in advanced manufactured products that belong to the same product category. However, as the low per capita income countries develop, that is, as their per capita income grows, they are expected to join the trade of the currently developed world in these sectors. Shifts toward intraindustry trade appear to be part of overall progress. Hence, they are likely to continue, even during periods when the aggregate global income elasticity of world trade is less than 1. Sectoral analysis of the measure also indicated potential increases in many product categories typically cited as examples of interindustry trade.

Nonetheless, the suspected lack of ergodicity in the AGIET time series also imparts an important restriction to its forecastability. The AGIET may remain above 1 during the next 5 years, or even until 2005, but it cannot remain above 1 forever. (Coincidently, the measure declines for purely arithmetic reasons as the ratio of trade to income increases.[24])

Modelers should consider major events in world trade, such as the East Asian financial crisis and the planned introduction of the EURO, when projecting the likely evolution of the AGIET. Such extensions would draw on the research conducted on the effects these developments are expected to have on global economic growth and trade. In general, continued research on the AGIET would allow appropriate adjustments in models designed to measure the future benefits of global trade liberalization.

Stability and Nonhomotheticity

Despite the empirical criticism leveled at homotheticity, long-horizon dynamic models (regardless of whether they are macroeconomic, general, or partial equilibrium models) require linear homogeneity. Any asymmetry built into the mechanics of equilibration through parameters that do not lead to a steady state is

[24] Given the formula $(\partial M/\partial Y)(Y/M)$; the ratio (Y/M) decreases as its reciprocal, the ratio of trade in world income, increases. A greater than unitary value of this index is expected to increase the ratio of trade in total income.

unsolvable. Therefore, in their terminal stages, steady state solutions must, *per force*, eliminate any tendencies for change. In particular, the final stage of meaningful solutions cannot feature increasing or decreasing returns to scale in consumption and production. The requirement for a steady state also includes traditional, static models whose solutions have the dynamic analogue implication "and so it could stay till eternity." The following briefly summarizes some known methods which can reconcile nonhomotheticity with the numerical requirements of economic modeling.

The logistic function.--The value of a logistic function decreases as time (the independent variable) increases. Therefore, a logistic function may be used to bring the nonhomothetic income elasticities into conformance with the steady state requirements of dynamic models. For an example of application--see Jorgenson (1997).

Flexible functional form (FFF) approaches.[25]--Applications in general equilibrium modeling are particularly noteworthy. They may be classified into two major groups: the use of FFF-estimated parameters with regularity restrictions imposed, and the diversification of parameters in functions with characteristics of global regularity. Trade-focused CGE models, pioneered by Robinson, et al. (1995) and Robinson, Soule, Weyerbrock (1992), relies upon the first approach. Using the Almost Ideal Demand System (AIDS), these models incorporate a safety system known as the Cholesky factorization. In case market shares stray out of the zero to one range, the Cholesky factorization, after duly signaling the occurrence, returns the algorithm to homothetic income elasticities--see Pogany (1996).

[25] In general, the FFF approach involves the "parametrization" of a suitable function with the help of data on the value of the function and on its first and second derivatives. In the case of consumption, the value of a linearly homogeneous cost function at a given set of prices is considered the total expenditure. The first derivatives of this function with regard to prices are demands for the various commodities, and the second derivatives are directly related to the price elasticities. The total expenditure and the data on demands and price elasticities form the basis of calculations. Elasticities recalculated ("recovered") in connection with solving general equilibrium models are of special significance, because they reflect the equilibrium conditions of the economy or economies considered. The assumption of the FFF approach is that a policy experiment, generating a new price vector, will not move the equilibrium point used to calculate the parameters so far from the initial reference point as to make the calculated curvature characteristics (that is, the gradient and the Hessian) inapplicable.

The Implicitly Directly Additive System (AIDADS) exemplifies the second approach. Using the linear expenditure system (LES) as the basic framework, Rimmer and Powell have designed a demand system that combines relative parameter flexibility with LES global regularity (Rimmer and Powell, 1992). They introduce estimated parameters that differentiate the simple marginal budget shares of discretionary expenditures, and by restricting these nonhomothetic parameters across the spectrum of commodity sectors, the sum of expenditure shares is still 1, thereby ensuring global regularity. This modeling strategy provides for variation of marginal budget shares and disperses income elasticities. Thus, the model provides for Engel curve relationships that differentiate between the demand for various goods.

However, after a sufficiently long time when subsistence-level expenditures become negligible compared to total expenditures, all the commodity-specific income elasticities revert to unity.[26] The length of time spent in the nonhomothetic phase, which depends on the relative size of the constant in the LES, may be estimated and artificially lengthened. For a description of this concept--see Benjamin and Pogany (1997).

The extended quasiconcave function.--This class of functions is often used to return the model from increasing (or decreasing) to constant returns to scale in production or consumption. This function looks as follows:

(7) $$Q = n\, f(x / n)$$

[26] For two product groups, the LES may be written as $X = a + b_1 (X-a) + b_2 (X-a)$. Subsistence expenditures are captured by "a," the marginal budget shares in the two-good example, which add up to 1, are b_1 and b_2, and the supernumerary income is (X-a). Dividing through with X results in $1 = a/X + b_1 (X-a)/X + b_2(X-a)/X$. When "a" becomes numerically insignificant relative to X, a/X vanishes and the remaining terms will become both marginal budget shares (since the X's cancel out) and average budget shares (if the calculations are carried out). The equality between marginal budget shares (marginal propensities to consume) and average budget shares (average propensity to consume) means unitary income elasticities. Thus, LES behaves "logistically."

Usually, nested CES functions or flexible functional form estimates are used to allocate spending on domestically-produced and imported goods within each product group. However, under the CES system, an increase in the overall ratio of imported goods is possible only if spending on product groups with relatively high import ratios increases faster than spending on the rest of the product groups. Even this possibility runs out when LES's nonhomothetic phase expires. The flexible functional form approach allows increases in the proportion of trade even when the LES enters its homothetic phase.

where n may be the number of consumers, and x the consumption vector. Although "*f*" may assume any shape under the definition of quasiconcavity, as long as it has only one peak and no "vertical" segments, the function is linearly homogeneous in n and x. To use this function as a long-run "normalizer" in a model featuring non unitary income elasticities, algebraic provisions must be made to increase x and n in the same proportion beyond a certain point in time. Per capita consumption will have to be considered fixed from that time on. For several applications of this approach in general equilibrium modeling--see Ginsburgh and Keyzer (1997).

Solutions developed in CGE models featuring imperfect competition.--Modeling increasing returns to scale on the production side of CGE models is a widely used practice. One of the most frequently used methods assumes that temporarily increasing returns to scale originate in the existence of an important level of fixed cost. Under this approach the steady state may be enforced by setting the marginal cost equal to the marginal revenue--for descriptions, see Cockburn (1995) and De Melo and Tarr (1992).

Similarly, the reestablishment of the equality between marginal and average propensities to consume may be achieved by specifying equality between the marginal rates of substitution and the price ratios among the terminal conditions. Such equalities imply homotheticity because they allow utility to be maximized according to the price ratios along indifference curves that are magnified or reduced versions of every other one, with rays leading through the origin. For an application of this method of guaranteeing the steady state condition in intertemporal optimization--see Devarajan and Go (1995).

Observations

(1) The level of a country's imports is determined by the prices of imports relative to domestic prices and domestic income levels. The level of a country's exports is determined by the prices of those exports relative to domestic prices elsewhere in the world and the income levels elsewhere. Therefore, any global analysis of the level of trade must deal with two types of effects, income and substitution effects. The

income effect represents the effect that changing levels of world income exert on the volume of trade. These changes in income may be a consequence of an expansion in global resources and/or an increased efficiency in their use through overall scientific-technological progress and/or improvement in the organization and management of production and distribution. In contrast, developments that affect the relative price ratios would produce price effects and price-change induced income effects.[27] Thus, price-change induced income effects are observed in the AGIET when measured as the ratio of the percentage change in imports to the percentage change in income, but not in the equation (3) estimates of ϵ_{Yj}.

(2) Applied research has demonstrated that greater than unitary income elasticities to import (or to export) have characterized the trade of the industrialized countries since World War II. And, given the dominance of the industrialized countries in overall world trade, this alone is sufficient to assert that greater than unitary value for the global aggregate global income elasticity of trade (that is, nonhomotheticity) prevailed in the postwar era. The shift of trade toward intraindustry exchanges during the epoch provides the *prima facie* evidence of nonhomotheticity, since intraindustry trade reflects a growing preoccupation with choice, a phenomenon closely tied with higher income levels. In contrast, the unitary AGIET, or the system of homothetic preferences, implies that the level of income has no effect on the structure of consumption, that is, on the structure of trade.

(3) The simple measure of the AGIET is the ratio of growth of world imports (or exports) to the growth in world income, measured in constant dollar terms. For 1980-1995, this measure was found to be at least 2.0. This measure overstates the aggregate global income elasticity of trade, because the observed change in imports (or exports) include changes brought about changes in relative prices. Thus, the AGIET will be less than that simple ratio. The AGIET should be calculated as the market-share-weighed average of

[27] Scientific-technological breakthroughs occurring in certain commodity groups; tariff changes or economic policies affecting only given regions or limited aspects of trade are the most typical manifestations of such developments.

national income elasticities to import. As the applied econometric literature attests, national income elasticities of trade have been most successfully derived for the industrialized countries. Consequently, the AGIET may be calculated from income elasticities of trade estimated for the industrialized countries, in combination with estimates and/or a range of assumptions for the rest of the world. These estimates vary according to the set of countries chosen, the econometric methodology deployed, and the assumptions adopted regarding the rest of the world. This variation may be used to establish a reasonable range for the AGIET estimates. For 1965-1993, the AGIET so derived was found to be at least 1.50, a value that may be characterized as "very strong."

(4) Whenever the AGIET exceeds unity, the use of the homothetic assumption in simulation models which purport to measure the consequences of trade policy alternatives will lead to an understatement of the economic growth and welfare benefits of trade liberalization. Such understatement is seen when comparing the actual growth of the world economy (which provides evidence for *de facto* nonhomotheticity) with the growth that would have been generated by using unitary AGIET. With continuous compounding, the homothetic preference-based model would have shown a minimum 10.3 percent less growth for the first 10 years, and a minimum 21.3 percent less growth for the first 20 years of the Tokyo Round (1980). The differences appear to be significant regarding the benefits attributable to the Uruguay Round. Estimates of the AGIET may also be used to evaluate the merits of trade liberalization (for example, tariff cuts) against the alternative of tax cuts on domestically sold products. It may also help estimate and analyze national or regional trade elasticities.

(5) The AGIET cannot remain above unity indefinitely. It will sometimes fall below unity. In a dynamic setting it cannot remain identical to unity. Nonetheless, a suspected lack of ergodicity in long-term AGIET time series, ascribing a certain inertia toward the steady state level, facilitates making short- and medium-term projections about its level. Major events in world trade, such as the East Asian financial crisis

or the likely emergence of a new world currency (EURO), always must be taken into consideration. Continued research on the AGIET would allow for an early signal of its eventual decline and for appropriate adjustments in models designed to analyze trade policy alternatives. Its breakout into regional income elasticities would serve as a crucial guide in evaluating regional trade and economic policy alternatives.

(6) Simulation modelers need to explore the use of specifications that are more flexible than the forms that are traditionally used, namely those that impose homotheticity as a maintained hypothesis. Alternative approaches reconcile nonhomotheticity with the algebraic requirements of steady state solutions. An Implicitly Directly Additive System, the extended quasiconcave function, the logistic function, and the methodology developed in modeling nonhomotheticity on the production side of general equilibrium models are some promising ways to achieve this synthesis. Applications of such model specifications by trade analysts would likely provide a set of simulation models that would be better able to replicate the post-World War II experience of growth in trade than the existing models.

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Table 10-1[28] Seemingly unrelated regression estimates (revised) [1]

Country	Real GDP	Real GDP shifter	GDP price index	Import price index	Constant	Constant shifter	R^2 [2]	DW	[3]
Argentina	***2.41*** ***(19.50)***	–	***0.05*** ***(6.94)***	***-0.71*** ***(-3.79)***	–	–	0.22	1.390	0.30
Canada	***2.23*** ***(26.95)***	–	*-0.22* *(-1.82)*	***-0.36*** ***(-4.51)***	–	–	0.76	1.535	0.22
Colombia	*2.08* *(2.45)*	-0.35 (-0.55)	***1.45*** ***(4.31)***	**-0.64** **(-2.38)**	***-0.31*** ***(-3.61)***	–	0.09	1.249	0.33
Côte d'Ivoire	***0.81*** ***(4.32)***	-0.27 (-0.94)	0.06 (0.70)	***0.45*** ***(3.43)***	-0.01 (-0.64)	–	0.26	1.898	0.05
France	***3.00*** ***(9.92)***	-0.38 (-1.19)	0.07 (0.66)	**-0.18** **(-2.51)**	–	–	0.36	1.252	0.36
Germany	***1.64*** ***(13.20)***	***-0.90*** ***(-6.83)***	0.12 (1.08)	0.05 (1.42)	–	***0.02*** ***(3.88)***	0.50	1.424	0.29
India	***0.67*** ***(7.39)***	***0.71*** ***(6.07)***	-0.10 (-1.01)	*0.14* *(1.92)*	–	–	0.18	1.044	0.47
Indonesia	***3.45*** ***(12.38)***	–	**0.34** **(2.49)**	0.03 (0.12)	***-0.18*** ***(-6.91)***	–	0.26	1.209	0.39
Italy	***2.50*** ***(19.32)***	–	0.00 (0.01)	***-0.22*** ***(-3.69)***	–	–	0.35	1.639	0.09
Japan	***2.98*** ***(13.46)***	–	***0.89*** ***(6.53)***	0.03 (0.40)	***-0.13*** ***(-6.85)***	***0.10*** ***(5.16)***	0.51	2.160	-0.11
Mexico	***6.03*** ***(29.57)***	***-2.14*** ***(-8.30)***	***0.23*** ***(9.70)***	***-0.83*** ***(-6.00)***	***-0.24*** ***(-9.10)***	***0.19*** ***(11.79)***	0.74	1.911	-0.00
Nigeria	***-2.64*** ***(-6.36)***	***3.66*** ***(6.41)***	***0.48*** ***(5.35)***	***-1.34*** ***(-3.07)***	***0.33*** ***(5.21)***	***-0.49*** ***(-9.18)***	0.23	2.088	-0.08
Pakistan	***1.10*** ***(6.62)***	–	***1.59*** ***(17.44)***	***-1.05*** ***(-6.60)***	***-0.11*** ***(-5.77)***	–	0.30	1.529	0.14
South Africa	***3.52*** ***(26.88)***	–	-0.12 (-1.64)	***-0.09*** ***(-3.07)***	***-.0.07*** ***(-4.80)***	***0.07*** ***(4.62)***	0.68	2.109	-0.13
Thailand	***3.04*** ***(14.08)***	–	-0.28 (-1.34)	*-0.23* *(-1.83)*	***-0.10*** ***(-4.88)***	–	0.42	2.575	-0.31
Turkey	***2.40*** ***(8.74)***	–	***0.44*** ***(3.56)***	***-0.53*** ***(-4.37)***	*-0.07* *(1.76)*	***-0.14*** ***(-3.49)***	0.34	1.470	0.24
U.K.	***1.18*** ***(10.64)***	–	***0.26*** ***(4.02)***	-0.00 (-0.05)	–	–	0.15	1.424	0.19
United States	***2.22*** ***(26.23)***	–	-0.09 (-0.95)	**-0.12** **(-2.65)**	–	–	0.77	2.313	-0.26
Zimbabwe	***1.23*** ***(17.27)***	–	0.07 (1.38)	**-0.25** **(-2.58)**	-0.01 (-0.40)	–	0.13	2.145	-0.18

1 Coefficients printed in *italics* are statistically significant at .10, coefficients printed in **bold** are statistically significant at .05, and coefficients printed in ***bold italics*** are statistically significant at .01 (two-tail test).

2 The R^2 reported are results of SUR estimations. They are coefficients of determination, measuring deviations between predicted and observed values. Their interpretation is analogous, but not identical, to that of coefficients of determination obtained from single equation OLS estimations.

3 Denotes the Cochrane-Orcutt serial correlation parameter.

Source: USITC staff calculations; see text for details.

[28] U.S. International Trade Commission (USITC), The Dynamic Effects of Trade Liberalization: An Empirical Analysis (332-275), USITC Publication No. 3069, Washington, October, 1997.

President's 1997 Economic Report (1960-1995) **GDP** **Trade**

Annual percentage change **3.8%** **6.1%**

GDP/Trade = Trade income elasticity of demand = **1.61**

given: **1.03800** * GDP = **1.06100** * Trade + d * Domestic

therefore d = 1.03225

1.03800 * GDP = 1.06100 * Trade + 1.03225 * Domestic

AGIET and Trade/GDP ξ: = **1.61**

Insert below the: econometric estimate of income elasticity to trade

price effect * **2.00** = **1.61**

or price effect = 0.8026

Y proportion = 0.7136

P proportion = 0.2864

P/Y = 0.40

ΔP = 0.40 * ΔY

1.061 = $(1+\Delta Y)(1+\Delta P)$ = $(1+\Delta Y)(1+\Delta Y^{*}$ 0.40) =

and 0.40 ΔY^2 + 1.40 ΔY - 0.061 = 0

roots: + $\sqrt{}$ = - 0.5693

- $\sqrt{}$ = 0.0069

ΔP = 0.40 * 0.0069 = 0.0028

1.061 = 1.0028 * 1.0581

if assume homothetic 1.03741 * GDP = 1.05806 * Trade + 1.03225 * Domestic

Implied growth rate in GDP **3.7%**