1986

Per-Capita Income as a Determinant of Trade

Linda Hunter

James R. Markusen

ISSN 0228-4235
ISBN 0-7714-0758-0

THE CENTRE FOR THE STUDY OF INTERNATIONAL ECONOMIC RELATIONS

WORKING PAPER NO. 8620C

PER-CAPITA INCOME AS A DETERMINANT OF TRADE

Linda Hunter

and

James R. Markusen

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the authors.

DEPARTMENT OF ECONOMICS
THE UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA
N6A 5C2

PER-CAPITA INCOME AS A DETERMINANT OF TRADE

Linda Hunter
Department of Economics
University of California, San Diego
La Jolla California

James R. Markusen
Department of Economics
University of Western Ontario
London Canada

ABSTRACT

A model is constructed to show how international differences in per-capita income can serve as a basis for trade. Tastes are assumed to be the same everywhere but budget shares depend on per capita income. A simple linear expenditure system is estimated for 34 countries over 11 commodity aggregates. Results suggest that deviations from homotheticity are significant in both statistical and economic terms. The latter results imply that non-homogeneity in demand is probably an important contributor to the overall volume and direction of trade. The implications of the results for several empirical problems are briefly explored.

July, 1986

Computation and Programming were performed by Kate Langdon and Atreya Chakraborty. The authors would also like to thank Lawrence Schembri, Robert Feenstra, Robert Lipsey and three referees for comments and suggestions.

1. INTRODUCTION

Both trade theory and empirical analyses in the Heckscher-Ohlin tradition have generally assumed that preferences are identical and homothetic across countries. If commodity prices are equalized by trade, commodities are consumed in the same proportion everywhere. Trade is then due solely to differences in production and its underlying determinants such as factor endowments. This "neutralization" of demand is of course a perfectly appropriate assumption to make if one wishes to concentrate on the consequences of some aspect of production. Indeed, it is often a useful methodology to concentrate on only a single aspect of technology such as the role of factor intensities and assume that other aspects such as production functions are the same across countries. Trade theory accordingly consists of a portfolio of simple models, each examining the role of one cause or "basis" for trade such as differences in factor endowments, differences in technologies, or increasing returns and production differentiation.

While we now view trade as having multiple bases, our theory has continued to concentrate on the production side of the economy with the assumption of identical, homothetic preferences (even if over a continuum of differentiated products) retained. Yet empirical estimations of demand systems consistently show large deviations from homotheticity or that certain commodity classes (e.g., food) absorb a much larger budget share at low per capita incomes (a good summary is found in Deaton and Muellbauer (1980)).

The first purpose of this paper is to create a model which shows how preferences can create a basis for trade. Since it is obvious that arbitrary differences in tastes across consumers can create a basis for trade, the approach of the paper will be to retain the assumption that preferences are the same everywhere, and instead drop the homotheticity assumption. Consistent with what appear to be the stylized facts, it will be assumed that the expenditure shares on goods depend on per capita income.

In order to get very far, we need to impose a good deal of structure on individual demand functions. Since the paper is ultimately motivated by international trade questions, we would like to have the property that a country's aggregate demand at given internal prices depends only on aggregate income, not on the distribution of income among groups of factor owners. If we want this aggregation condition to hold and have non-homotheticity, we are left with the linear expenditure system (Gorman polar form). This is a restrictive demand system but it does possess some extremely convenient analytical properties in addition to permitting perfect aggregation. It is simultaneously true that some of the linear expenditure system's (LES) restrictions that have been a source of criticism are of little consequence for the purposes of this paper. An example of this is the LES's restriction on elasticities of substitution between pairs of commodities.

Having shown how per capita income can serve as a basis for trade, the second purpose of the paper is to estimate a simple LES using international cross section data and use the results to assess both the statistical and the economic significance of the deviations from homotheticity. This estimation is performed for 34 countries with 11 commodities using the real-exchange-rate corrected 1975 data of Kravis, Heston, and Summers. In addition to providing us with real exchange rates, this data set has the exceptional property that comparable prices are given for comparable commodity aggregates. In addition to the full system, two restricted versions are estimated for use in likelihood ratio tests. In one version, all relative price terms are collapsed into a single constant term (referred to below as Restricted Version A). In the second, all non-income terms are suppressed so that expenditures are estimated as a function of income only (referred to below as Restricted Version B). The latter is the homogeneous (also Cobb-Douglas) version of the general LES.

Results indicate that the estimated LES deviates substantially from homotheticity in both statistical and economic terms. From a statistical point of view, equation-by-equation likelihood ratio tests are used to compare the full LES to the two restricted versions. Results differ by equation, but there are reasonably strong grounds to reject homogeneity. A system likelihood ratio test on Restricted Versions A versus B rejects the maintained hypothesis of homogeneity at the 1% level.

From the point of view of economic significance, we construct what we call a "volume-of-trade" counterfactual experiment. Suppose that all 34 countries were endowed with the 11 commodities in the same proportions. This reverses the normal argument and neutralizes the production side of the model as a possible cause of trade. Using the fitted values of consumption from the estimated LES (thereby eliminating trade caused by differences in tastes and differences in domestic prices) we then calculate the equilibrium level of free trade that must occur given the proportional production assumption. This equilibrium level of trade amounts to 14.4% of the combined total consumption expenditures of the 34 countries. We regard this (counterfactual) level of trade, caused only by the systematic differences in demand due to differences in per capita income, as a significant result. That is, we tentatively conclude that demand sources of trade may indeed contribute in a significant way to the overall volume and direction of trade. For comparison purposes, the same experiment is performed using actual consumption data, thereby including trade caused by differences in preferences and differences in relative prices (which may either reinforce or counteract the trade caused by differences in per capita income). The equilibrium level of trade in this case amounted to 13.4% of combined consumption expenditures.

The paper concludes with a section detailing six applications and implications of the LES estimation. First, it is emphasized again that per capita income differences probably do constitute an empirically significant determinant of trade flows and thus do deserve to be included in our general theory of the causes of trade. Second, this finding may help to shed some light on the so-called Linder hypothesis (1961). Linder's model is complex, but differences in per capita income among countries are a key element in the story. Independently of other elements of the Linder theory, the present paper does offer some support to the notion that countries with similar per capita incomes consume similar bundles of goods. Third, the notion that income elasticities of demand for goods are not unity (i.e., preferences are not homothetic) is a key element to the so-called Prebisch-Singer hypothesis (Prebisch (1964), Singer (1950)) on the North-South terms of trade. As in the case of Linder, certain elements in the Prebisch-Singer thesis are questionable. But the present paper does provide support for the notion long-term growth in world per capita incomes will have an effect on commodity terms of trade due to non-homotheticity.

Fourth, it is noted that the LES demand estimates can easily be integrated with Leamer's (1984) estimates of the relationship between trade vectors and endowment vectors. This would allow us to decompose the trade vector into the sum of two vectors: one being the Heckscher-Ohlin trade vector in the usual sense and the other being the contribution to trade of differences in per capita income. Fifth, the relevance of the results to "Leontief Paradox" type findings are noted. If labor intensive goods are also goods which have high "minimum consumption requirements" (low income elasticities of demand), then low per-capita income, labor abundant countries will "specialize" in consuming labor intensive goods as well as specialize in producing these goods. It is thus possible for the normal Heckscher-Ohlin pattern of trade to be reversed even though the latter model does correctly predict the pattern of specialization in production.

Sixth and closely related to the previous point, the model may help to explain the high volume of trade among the industrialized countries relative to North-South trade. If the labor-abundant South tends to specialize in both the production and the consumption of the same class of commodities, then the volume of the North-South trade is thereby reduced. Yet "East-West" trade volumes can simultaneously be large if that trade is based on differentiated manufactured goods and services (Markusen (1985)). Both of these last points depend upon a correlation between labor intensity in production and low income elasticity of demand in consumption (as does the Prebisch-Singer hypothesis). We hope to examine this relationship in future work.

2. PER-CAPITA INCOME AS A BASIS FOR TRADE

The linear expenditure system is derived from a simple Cobb-Douglas utility function for which the origin has been displaced. Let

C_i denote the consumption of good i and let $\bar{C}_i$ denote a "minimum consumption requirement" for good i. The consumer's utility function is then given by

$$(1)\quad U(C) = \prod_{i=1}^{n} (C_i - \bar{C}_i)^{\beta_i} \;; \qquad \Sigma\beta_i = 1.$$

Indifference curves and the income-consumption path at price ratio p^* are illustrated in Figure 1. The income-consumption path is linear but it need not go through the origin. The utility function in (1) yields the following demand function for C_i.

$$(2)\quad C_i = \bar{C}_i + \beta_i(I - \Sigma p_j\bar{C}_j)/p_i$$

where I is the consumer's income. The term $(I - \Sigma p_j\bar{C}_j)$ is interpreted as income available after meeting minimum consumption requirements.

Since, at a common set of prices, each individual's consumption of a good is the same linear function of income, the demand functions (2) permit perfect aggregation into a market demand function of the same form. That is, the internal distribution of income within a country does not affect market demands provided that (A) all individuals face the same prices and (B) each individual has enough income to purchase the minimum consumption requirements. Thus I and the C_i's in (2) can be interpreted as a country's total income and consumption, or dividing through by population, interpreted as per capita variables. The latter interpretation will be used throughout the remainder of the paper unless otherwise indicated.

Figure 2 indicates how differences in per capita income can serve as a basis for trade. The minimum consumption requirement for C_1 is positive while that for C_2 is zero as shown. C_1 is thus a "necessity" with an income elasticity of demand less than one while C_2 is a "luxury" with an income elasticity of demand greater than one. Different countries are assumed

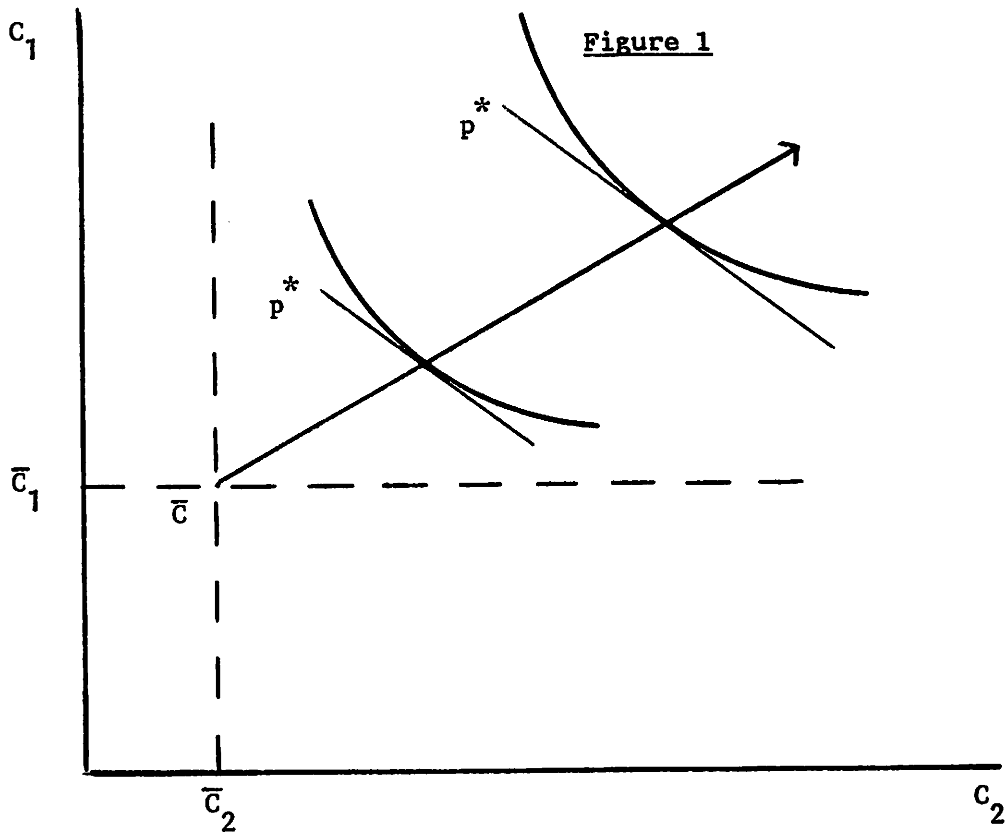


Figure 1
c1
p*
p*
c̄1
c̄
c̄2
c2

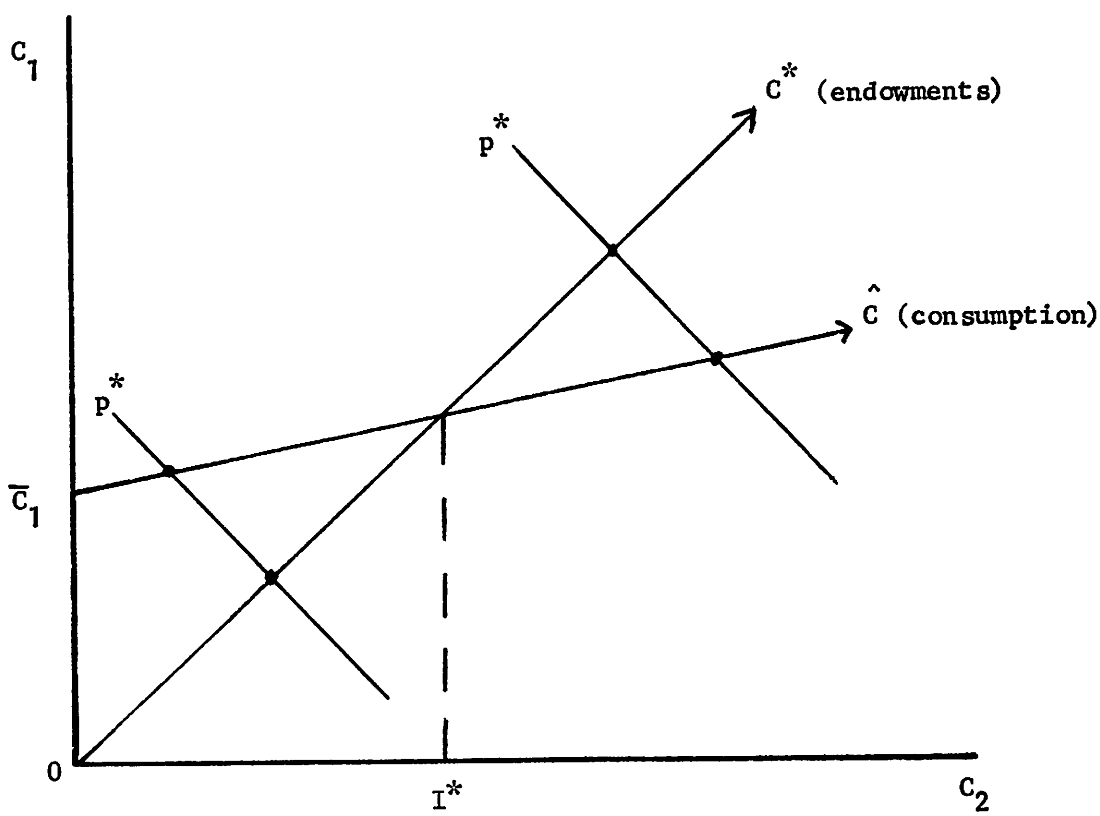


Figure 2
c1
c* (endowments)
p*
ĉ (consumption)
p*
c̄1
0
I*
c2

to be endowed with C_1 and C_2 in the same proportion in Figure 2, but with different absolute amounts per capita. Per capita endowments thus lie along the ray OC^* through the origin. If we permit free trade, the consumption bundles at the resulting free-trade prices will lie along $\bar{C}\hat{C}$. Countries with per-capita endowments below I^* will export C_2 and import C_1 and vice versa for countries with per capita incomes in excess of I^*. This trade is due to differences in per capita income (differences in absolute endowments) and originates from the demand side of the model. The total volume of trade is larger as the degree of non-homogeneity increases and as the differences in per capita income increase.

3. ESTIMATION OF A LINEAR EXPENDITURE SYSTEM

Estimation of LES's and demand systems using other functional forms are typically carried out using time series data for a single country. For the purposes of this study, we wanted international cross-section data so that we could have a much wider range of per capita income and so as to not exclude possibly large amounts of "noise" due to differences in tastes, etc. The problem with international data, however, is that exchange rate converted income numbers are often far off from the "real" or "purchasing power parity" comparisons one desires. To get around this problem, we used real exchange rate figures for 1975 derived by Kravis, Heston, and Summers (1982). As noted in the introduction, this data is exceptional in that for 34 countries we are given comparable real prices on comparable commodity aggregates. For the purposes of this paper, we used 11 commodity aggregates for the 34 countries. The countries are listed in Table 1 and the commodities are given together at the end of Table 2. It should be emphasized that the data is on consumption expenditures and thus does not consider the decision to divide income between consumption and savings. Total expenditures on the 11 goods sum up to total expenditures (referred to as "income") by the definition of the data.

The equations in (2) can be written as

$$(3) \quad p_i C_i = \sum_{j=1}^{11} \alpha_{ij} p_j + \beta_i I$$

Where the p_i and C_i are price and consumption of good i, respectively. I is income, where all of p_i, C_i, and I are in real U.S. dollars per capita. Units are chosen in the data so that all U.S. prices are equal to one. It follows from equation (2) that α_{ii} and α_{ij} are defined as

$$(4) \quad \alpha_{ii} \equiv (1 - \beta_i) p_i \bar{C}_i ; \qquad \alpha_{i} \equiv -\beta_i p_j \bar{C}_j \quad \text{for } i \neq j.$$

In each country, the price of food (good 1) was used as numeraire so that the actual regressors were p_i/p_1 and I/p_1. Since the $p_i C_i$ sum to I for each country, independent OLS estimation of (3) for each commodity will generate estimates that automatically satisfy the adding-up restrictions that

$$(5) \quad \sum_i \beta_i = 1, \qquad \sum_i \sum_j \alpha_{ij} = 0.$$

The range of real incomes (I) and food consumption per capita ($p_i C_i$) are given in Table 1 as INCOME and FOOD respectively. FS is the share of food in total consumption expenditures (income). Eyeballing the data we see that this share declines with per capita income, although there are, of course, price differences across the countries.

Results of the OLS estimation are given in Table 2. R-squared and log of likelihood function (used later) results are presented along with the estimated coefficients and T-statistics. The income coefficients given the marginal expenditure shares (β_i). If all countries had U.S. relative prices

TABLE 1

Real Per-capita Incomes (Income), Food Expenditure Per Capita (FOOD), Share of Food Expenditures (FS), and Fitted Share of Food Expenditures (FFS) at U.S. Prices

COUNTRY		INCOME	FOOD	FS	FFS
Malawi	*	285.56119	150.95821	0.52864	1.11662
India	*	352.67599	212.78401	0.60334	0.92295
Kenya	*	379.53186	139.91690	0.36866	0.86464
Zambia	*	431.98636	163.84352	0.37928	0.77166
Pakistan	*	459.34641	260.92471	0.56803	0.73159
Sri Lanka	*	532.61249	319.39999	0.59969	0.64456
Philippines	*	720.64258	390.10645	0.54133	0.50220
Thailand	*	726.23615	311.12503	0.42841	0.49909
Malaysia	*	975.66388	333.04099	0.34135	0.39679
Korea	*	1065.69629	473.47644	0.44429	0.37163
Brazil	*	1267.28625	430.08286	0.33937	0.32825
Columbia	*	1321.71680	447.63895	0.33868	0.31880
Syria	*	1347.55298	640.13635	0.47504	0.31459
Jamaica	*	1385.28772	436.25723	0.31492	0.30871
Iran	*	1398.34375	452.10315	0.32331	0.30675
Romania	*	1498.07898	526.81580	0.35166	0.29292
Yugoslavia	*	1782.39795	505.66327	0.28370	0.26197
Mexico	*	1921.08337	707.48615	0.36827	0.25020
Poland	*	2240.15161	642.37122	0.28675	0.22866
Uruguay	*	2323.31738	740.02887	0.31852	0.22401
Ireland	*	2394.14746	552.30054	0.23069	0.22031
Hungary	*	2410.90991	635.12610	0.26344	0.21947
Italy	*	2742.31934	795.93829	0.29024	0.20490
Japan	*	3033.02954	675.71954	0.22279	0.19474
Spain	*	3117.61816	930.52264	0.29847	0.19214
United Kingdom	*	3296.31860	540.70721	0.16403	0.18709
Netherlands	*	3530.42017	588.25000	0.16662	0.18124
Austria	*	3828.98071	638.28845	0.16670	0.17483
Belgium	*	3861.73926	725.77979	0.18794	0.17418
Germany	*	3887.29395	591.41577	0.15214	0.17369
France	*	3891.01294	734.84668	0.18886	0.17362
Denmark	*	4041.83789	637.92981	0.15783	0.17083
Luxembourg	*	4086.55054	767.55859	0.18783	0.17004
United States	*	5159.62012	658.25000	0.12758	0.15525

TABLE 2: FULL ESTIMATED LINEAR EXPENDITURE SYSTEM

Equation 1, Dependent Variable G1 = Food.

R-SQUARED = 0.887184
LOG OF LIKELIHOOD FUNCTION = -191.630

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	248.71	87.27	2.850
P2	-98.93	43.48	-2.275
P3	-29.63	77.54	-0.382
P4	-85.00	65.75	-1.293
P5	-21.01	36.85	-0.570
P6	265.90	75.13	3.539
P7	-116.69	100.99	-1.155
P8	-47.95	62.34	-0.769
P9	34.84	91.80	0.380
P10	62.80	141.09	0.445
P11	77.58	173.32	0.448
INCOME	0.099	0.032	3.11

Equation 2, Dependent Variable G2 = Beverages and Tobacco

R-SQUARED = 0.761051
LOG OF LIKELIHOOD FUNCTION = -172.360

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	15.70	49.51	0.317
P2	21.02	24.67	0.852
P3	21.82	43.99	0.496
P4	-2.17	37.30	-0.058
P5	-20.73	20.91	-0.992
P6	17.57	42.62	0.412
P7	-58.46	57.30	-1.020
P8	30.65	35.37	0.867
P9	-24.42	52.08	-0.469
P10	-27.16	80.05	-0.339
P11	-47.79	98.33	-0.486
INCOME	0.060	0.018	3.331

Equation 3, Dependent Variable G3 = Clothing, Footwear

R-SQUARED = 0.910264
LOG OF LIKELIHOOD FUNCTION = -166.375

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	48.07	41.52	1.158
P2	-15.20	20.69	-0.735
P3	12.52	36.89	0.339
P4	-52.88	31.28	-1.690
P5	-6.64	17.53	-0.379
P6	7.38	35.74	0.206
P7	14.78	48.05	0.308
P8	21.57	29.66	0.727
P9	-6.88	43.68	-0.157
P10	-14.50	67.13	-0.216
P11	-7.25	82.46	-0.088
INCOME	0.076	0.015	4.998673

Equation 4, Dependent Variable G4 = Gross Rent

R-SQUARED = 0.928209
LOG OF LIKELIHOOD FUNCTION = -180.080

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-55.31	62.14	-0.890
P2	47.85	30.96	1.545
P3	-47.64	55.21	-0.863
P4	133.34	46.81	2.848
P5	-20.26	26.24	-0.772
P6	-93.65	53.49	-1.751
P7	-86.03	71.91	-1.196
P8	-20.05	44.39	-0.452
P9	112.13	65.36	1.716
P10	-54.66	100.46	-0.544
P11	-67.35	123.40	-0.546
INCOME	0.149	0.022	6.589

Equation 5, Dependent Variable G5 = Fuel, Power

R-SQUARED = 0.921574
LOG OF LIKELIHOOD FUNCTION = -145.266

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-38.21	22.32	-1.712
P2	8.76	11.12	0.788
P3	6.46	19.83	0.326
P4	8.11	16.81	0.482
P5	9.41	9.42	0.999
P6	2.92	19.21	0.152
P7	-18.04	25.83	-0.698
P8	-15.17	15.94	-0.951
P9	19.83	23.47	0.845
P10	74.58	36.08	2.067
P11	-13.68	44.32	-0.308
INCOME	0.027	0.008	3.376

Equation 6, Dependent Variable G6 = Household Furnishing, Operation

R-SQUARED = 0.946564
LOG OF LIKELIHOOD FUNCTION = -163.452

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-27.14	38.10	-0.712
P2	-35.70	18.98	-1.881
P3	83.99	33.85	2.481
P4	-47.57	28.71	-1.657
P5	16.10	16.09	1.001
P6	-2.48	32.80	-0.076
P7	25.46	44.09	0.577
P8	-14.24	27.22	-0.523
P9	-12.79	40.08	-0.319
P10	110.00	61.60	1.786
P11	12.41	75.67	0.164
INCOME	0.056	0.014	4.009

Equation 7, Dependent Variable G7 = Medical Care

R-SQUARED = 0.930830
LOG OF LIKELIHOOD FUNCTION = -173.915

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-54.93	51.83	-1.060
P2	10.85	25.82	0.420
P3	-23.11	46.05	-0.502
P4	-36.85	39.05	-0.944
P5	26.72	21.89	1.221
P6	-36.93	44.62	-0.828
P7	200.66	59.98	3.345
P8	9.98	37.03	0.270
P9	-85.92	54.52	-1.576
P10	-204.06	83.80	-2.435
P11	65.97	102.94	0.641
INCOME	0.137	0.019	7.262

Equation 8, Dependent Variable G8 = Transportation, Communication

R-SQUARED = 0.972144
LOG OF LIKELIHOOD FUNCTION = -163.187

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-37.25	37.81	-0.985
P2	12.47	18.84	0.662
P3	-0.26	33.59	-0.008
P4	34.35	28.48	1.206
P5	15.14	15.96	0.948
P6	-78.77	32.54	-2.420
P7	43.15	43.75	0.986
P8	33.20	27.01	1.229
P9	42.02	39.77	1.057
P10	-52.62	61.12	-0.861
P11	-133.11	75.08	-1.773
INCOME	0.146	0.014	10.630

Equation 9, Dependent Variable = Recreation

R-SQUARED = 0.939699
LOG OF LIKLIHOOD FUNCTION = -155.887

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-49.04	30.50	-1.608
P2	20.25	15.20	1.332
P3	-12.59	27.10	-0.465
P4	-4.54	22.98	-0.198
P5	2.02	12.88	0.157
P6	-3.07	26.26	-0.117
P7	4.07	35.30	0.115
P8	-4.92	21.79	-0.228
P9	-59.53	32.08	-1.856
P10	-51.65	49.31	-1.047
P11	116.08	60.57	1.916
INCOME	0.073	0.011	6.528461

Equation 10, Dependent Variable G10 = Education

R-SQUARED = 0.910541
LOG OF LIKELIHOOD FUNCTION = -171.078

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-32.68	47.68	-0.685
P2	22.81	23.76	0.960
P3	-23.35	42.36	-0.551
P4	8.32	35.92	0.232
P5	-15.35	20.13	-0.762
P6	-33.37	41.05	-0.813
P7	-19.78	55.18	-0.358
P8	-19.17	34.06	-0.563
P9	-34.44	50.15	-0.687
P10	99.19	77.09	1.287
P11	145.60	94.69	1.538
INCOME	0.055	0.017	3.149

Equation 11, Dependent Variable G11 = Other Expenditures

R-SQUARED =	0.923316
LOG OF LIKELIHOOD FUNCTION =	-180.726

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
P1	-17.93	63.33	-0.283
P2	5.83	31.55	0.185
P3	11.80	56.27	0.210
P4	44.90	47.71	0.941
P5	14.61	26.74	0.546
P6	-45.49	54.52	-0.834
P7	10.88	73.29	0.148
P8	26.08	45.24	0.577
P9	15.17	66.61	0.228
P10	58.06	102.38	0.567
P11	-148.48	125.77	-1.181
INCOME	0.123	0.230	5.323

IMPLIED INCOME ELASTICITIES OF DEMAND AT MEAN INCOME
AND MEAN CONSUMPTION LEVELS

FOOD	0.452
BEV & TABAC	1.225
CLOTH & FOOT	1.004
GROSS RENT	1.741
FUEL & POWER	0.806
HOUSE FURN	0.758
MEDICAL	1.907
TRANS & COMM	1.722
RECREATION	1.422
EDUCATION	0.870
OTHER EXP	1.249

$(p_i/p_1) = 1$), then we could sum all of the price terms together, and add per capita income times the INCOME coefficient to get a country's fitted consumption values. These will be used later in our volume-of-trade exercise. Dividing these fitted values for food consumption by income gives us a fitted share of food consumption at U.S. relative prices which is reproduced in Table 1 as the right-hand column (FFS). These values decline sharply with income indicating an income elasticity of demand for food of less than one (the value of FFS greater than one for Malawi indicates that Malawi does not have enough income at U.S. prices to consume the minimum consumption requirement of food).

The results of the 11 equations are not easy to interpret in Table 2 because of the many regressors. One simple summary statistic which is relevant to this paper is the implied income elasticities of demand for the goods. These are, however, not constants in the LES system. A simple solution is to evaluate these elasticities at the mean consumption and income levels. Results are shown at the end of Table 2. Deviations from unity (preference deviation from homotheticity) seem to be significant in economic terms. This is a loose statement that we shall attempt to make more precise in the section on the volume-of-trade experiment.

The results of Table 2 are also not easily interpreted in terms of statistical significance. The large number of regressors are at least partly responsible for the low T-statistics on the relative price terms. To examine the overall significance of the price terms, we ran the system of equations a second time with all of the price terms collapsed into a single constant term. This system, referred to as Restricted Version A, thus has just a constant and per capita income as the regressors. Results are given in

Table 3. Note that the T-statistics on the constant term are statistically significant in the majority of the cases. A third verison of the problem was estimated using income terms only as regressors, reflecting the maintained hypothesis that demand is homothetic (of course, the LES preferences are also part of the maintained hypothesis). This system is known as Restricted Version B and results of the estimation are given in Table 4.

The hypothesis of homogeneity is a hypothesis about the entire system of equations and as such the T-statistics on the individual relative price terms do not directly address the hypothesis. Accordingly, we used likelihood ratio testing to test the two restricted versions of the model against the full LES system. Twice the difference in the values of the log of likelihood functions is asymptotically χ^2_n with n degrees of freedom, where n is the number of restrictions.

Results of the likelihood ratio tests are presented in Table 5. The first three columns reproduce the log of likelihood function (LLF) for each equation from Table 3 (Restricted Version A), Table 4 (Restricted Version B), and Table 2 (Unrestricted or full LES). The fourth column gives twice the difference between the LLFs for the Restricted Version A and the Unrestricted system. This is essentially testing the hypothesis that the 11 relative price terms contribute no more explanatory power than a single constant term (hence 10 degrees of freedom in the Chi-squared test). This hypothesis can be rejected at the 5% level for four equations and at the 25% level for 8 of the 11 equations.

The fifth column of Table 5 gives twice the difference between the LLFs for the Restricted Version B (income term only) and the Unrestricted system. This tests the assumption that preferences are homothetic, restricting all

11 relative price terms to zero (hence 11 degrees of freedom). As shown, this hypothesis can be rejected at the 5% level for 6 of the 11 equations and at the 25% level for 9 of the 11 equations.

It was also possible to do a system test on Restricted Version A versus Restricted Version B, testing the joint hypothesis that the intercept coefficients of all ten equations in the former system are jointly zero (i.e., demand is homothetic). The first 10 equations (the system is singular so one equation is redundant) were estimated simultaneously as if we had a system of seemingly unrelated regression equations (SUR). The independent variable, income, is the same for all equations, hence OLS is efficient (Harvey (1981)). The SUR estimating technique yields exactly the same estimated coefficients as those reported in Tables 2 and 3 (T-statistics differ slightly). But the simultaneous estimation allows for the log likelihood function generated by the system to be estimated. We first estimate the system in its Restricted Version B generating the LLF given at the bottom of Table 5. We then estimate the Restricted Version A to obtain its corresponding LLF, also given at the bottom of Table 5. The Chi-square test statistic with 10 degrees of freedom (10 intercept coefficients forced to zero) is significant at the 1% level. Subject, of course, to the functional form used, data limitations and so forth, we thus statistically reject the homogeneity hypothesis.

TABLE 3: RESTRICTED LES, VERSION A: CONSTANT PLUS INCOME TERM

Equation 1, Dependent Variable G1, Food.

R-SQUARED = 0.721270
LOG OF LIKELIHOOD FUNCTION = -207.007

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	220.88	32.46	6.804
INCOME	0.125	0.014	9.010

Equation 2, Dependent Variable G2, Beverages and Tabacco

R-SQUARED = 0.620269
LOG OF LIKELIHOOD FUNCTION = -180.234

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONS	16.33	14.77	1.106
INCOME	0.045	0.062	7.230

Equation 3, Dependent Variable G3, Clothing and Footwear

R-SQUARED = 0.886835
LOG OF LIKELIHOOD FUNCTION = -170.319

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	17.34	11.03	1.571
INCOME	0.074	0.047	15.836

Equation 4, Dependent Variable G4, Gross Rent

R-SQUARED = 0.883561
LOG OF LIKELIHOOD FUNCTION = -188.302

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTAN	-57.10	18.73	-3.049
INCOME	0.123	0.079	15.583

Equation 5, Dependent Variable G5, Fuel and Power

R-SQUARED = 0.887039
LOG OF LIKELIHOOD FUNCTION = -151.469

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	-10.09	6.34	-1.592
INCOME	0.042	0.003	15.852

Equation 6, Dependent Variable G6, Household Furnishings and Operation

R-SQUARED = 0.906722
LOG OF LIKELIHOOD FUNCTION = -172.923

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	-16.33	11.91	-1.371
INCOME	0.089	0.005	17.637

Equation 7, Dependent Variable G7, Medical Care

R-SQUARED = 0.858922
LOG OF LIKELIHOOD FUNCTION = -186.032

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	-47.55	17.52	-2.714
INCOME	0.103	0.00	13.958

Equation 8, Dependent Variable G8, Transportation and Communication

R-SQUARED = 0.957142
LOG OF LIKELIHOOD FUNCTION = -170.511

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	-45.51	11.10	-4.101
INCOME	0.125	0.005	26.733

Equation 9, Dependent Variable G9, Recreation

R-SQUARED =	0.912210
LOG OF LIKELIHOOD FUNCTION =	-162.273

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	-21.79	8.709	-2.502
INCOME	0.067	0.004	18.235

Equation 10, Dependent Variable G10, Education

R-SQUARED =	0.831733
LOG OF LIKELIHOOD FUNCTION =	-181.818

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	-25.82	15.47	-1.669
INCOME	0.082	0.007	12.577

Equation 11, Dependent Variable G11, Other Expenditures

R-SQUARED =	0.908212
LOG OF LIKELIHOOD FUNCTION =	-183.783

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-STATISTIC
CONSTANT	-30.35	16.40	-1.851
INCOME	0.123	0.007	17.794

TABLE 4: RESTRICTED LES, VERSION B: INCOME TERM ONLY

VARIABLE	ESTIMATED INCOME COEFFICIENT	T-STATISTIC	R-SQUARED	LLF
FOOD	0.201	16.36	0.318	-222.218
BEV & TOBAC	0.051	13.952	0.606	-180.872
COTH & FOOT	0.080	28.835	0.878	-171.582
GROSS RENT	0.104	20.165	0.850	-192.637
FUEL & POWER	0.039	24.500	0.878	-152.765
HOUSE FURN	0.083	28.074	0.901	-173.894
MEDICAL	0.087	18.521	0.826	-189.554
TRANS & COMM	0.110	33.119	0.935	-177.692
RECREATION	0.060	25.902	0.895	-165.310
EDUCATION	0.073	18.814	0.817	-183.236
OTHER EXP	0.112	27.066	0.898	-185.512

TABLE 5: LIKELIHOOD RATIO TESTS OF HOMOGENEITY RESTRICTIONS

VARIABLE	LLF RES A	LLF RES B	LLF UNRES	CHI-SQUARE TEST STAT A 10 D.F.	CHI-SQUARE TEST STAT B 11 D.F.
FOOD	-207.007	-222.218	-191.630	30.75***	61.18***
BEV & TOBAC	-180.234	-180.872	-172.360	15.77*	17.03*
CLOTH & FOOT	-170.319	-171.582	-166.375	7.89	10.41
GROSS RENT	-188.302	-192.637	-180.808	16.44**	65.11***
FUEL & POWER	-151.469	-152.765	-145.266	12.41	15.00*
HOUSE FURN	-172.923	-173.894	-163.452	18.94***	20.88***
MEDICAL	-186.032	-189.554	-173.915	24.22***	31.28***
TRANS & COMM	-170.511	-177.692	-163.187	14.65*	29.01***
RECREATION	-162.273	-165.310	-155.887	12.77*	18.85**
EDUCATION	-181.818	-183.236	-171.078	21.48***	24.32***
OTHER EXP	-183.783	-185.512	-180.726	6.11	9.75

Chi-square Critical Values	Chi-square Test Stat A	Chi-square Test Stat B
25% *	12.5	13.7
10% **	16.0	17.3
05% ***	18.3	19.7

SYSTEM LIKELIHOOD RATIO TEST ON RESTICTED VERSION A VERSUS VERSION B USING SEEMINGLY UNRELATED REGRESSIONS (SUR)

SUR LLF VERSION B	SUR LLF VERSION A	CHI-SQUARE TEST STAT (10 D.F.)
-1686.50	-1667.98	37.04 (Significant at 1% level)

4. A COUNTERFACTUAL VOLUME-OF-TRADE EXPERIMENT

The purpose of this section is to attempt to assess the economic as opposed to the statistical significance of the results presented in Table 2. We do this by posing a counterfactual question of the type outline in the Introduction. Suppose that all 34 countries in the sample were endowed with the 11 commodities in the same proportions. Assume further that we are observing a free-trade equilibrium in which commodity prices are the same everywhere. We can then add the consumption bundles of the countries together to get total world income and the total world endowment of each commodity. Each country is then given a share of this world endowment bundle in a proportion to its share of world income. The difference between a country's actual consumption bundle and its hypothetical endowment is then its trade vector. In terms of Figure 2, and endowment bundle along OC^* is calculated for each country and a trade vector linking the consumption and the endowment point is calculated in value terms. It must be emphasized that these trade vectors are in no sense empirical estimates of demand induced trade. They are artifical measures constructed to give us some understanding of the degree of preference non-homogeneity found in the data.

By summing the value of each country's exports and summing over countries, we then have a statistic for the value of world trade. Summing over imports yields the same answer since trade is balanced. So alternatively, we can sum the absolute value of all excess demands and divide by two. Dividing this statistic by the total value of world consumption, we then have trade as a percentage of total consumption expenditures. Let C_{ij} denote the per capita consumption of good i by country j and let X_{ij} denote the per capita endowment of good i in country j. Each country is treated as if it were a single individual (i.e., observations are not weighted by population). Our share-of-trade statistic is then given by

$$(6) \quad \frac{\Sigma_i \Sigma_j |p_i C_{ij} - p_i X_{ij}|/2}{\Sigma_i \Sigma_j p_i C_{ij}} \text{ where } X_{ij} \equiv s_j \Sigma_j C_{ij} \text{ and } s_j \equiv \frac{\Sigma_i p_i C_{ij}}{\Sigma_i \Sigma_j p_i C_{ij}}$$

s_j is country j's share of total world consumption expenditure (income). These shares sum to one by definition. X_{ij} is country j's hypothetical endowment of good i. Note from this definition that country j is "endowed" with the same share of all goods. Hence there is no trade caused by the production side of the model.

The volume of trade statistic is calculated in two different ways. First, we simply use the actual observations on consumption from the data. This will generate trade caused not only by differences in per capita income but also trade caused by differences in preferences and differences in relative prices. Using this method, the statistic in (6) yields a figure of 13.4%. Table 6 gives an example of how this statistic is calculated for good 1, food. Each country's food consumption per capita is given from the data (column (A)). The country's share of total world consumption expenditure is calculated from the data as given in (6). The food consumption figures in (A) are then summed to give the total world endowment of food. This total times country j's share in column (B) gives country j's hypothetical endowment of food (column (C)). The difference between consumption (A) and the endowment of food (C) gives j's hypothetical imports of food (D). The numbers in column (D) sum to zero by definition.

To summarize, columns (A) and (B) in Table 6 are given by or calculated from the data while columns (C) and (D) are constructed. This procedure is then repeated for the other 10 goods, and the positive elements of column (D) are summed over all goods to give the total volume of world imports. Dividing this number by total world consumption gives the total volume of trade.

TABLE 6:

AN EXAMPLE OF THE VOLUME-OF-TRADE COUNTERFACTUAL CALCUATIONS FOR THE FOOD SECTOR (ACTUAL CONSUMPTION DATA)

COUNTRY	(A) CONSUMPTION OF FOOD PER CAPITA (ACTUAL)	(B) "SHARE OF WORLD INCOME"	(C) IMPLIED ENDOWMENT OF FOOD PER CAPITA (B)X(SUM(A))	(D) IMPORTS OF FOOD PER CAPITA (A)-(C)
Malawi	150.95821	0.00398	70.72337	80.23484
India	212.78401	0.00492	87.34532	125.43869
Kenya	139.91690	0.00529	93.99657	45.92034
Zambia	163.84352	0.00603	106.98769	56.85584
Pakistan	260.92471	0.00641	113.76379	147.16092
Sri Lanka	319.39999	0.00743	131.90919	187.49080
Philippines	390.10645	0.01005	178.47758	211.62886
Thailand	311.12503	0.01013	179.86292	131.26212
Malaysia	333.04099	0.01361	241.63730	91.40369
Korea	473.47644	0.01486	263.93512	209.54132
Brazil	430.08286	0.01768	313.86179	116.22107
Columbia	447.63895	0.01843	327.34232	120.29664
Syria	640.13635	0.01880	333.74103	306.39532
Jamaica	436.25723	0.01932	343.08658	93.17065
Iran	452.10315	0.01950	346.32010	105.78307
Romania	526.81580	0.02089	371.02097	155.79483
Yugoslavia	505.66327	0.02486	441.43668	64.22660
Mexico	707.48615	0.02679	475.78412	231.70203
Poland	642.37122	0.03124	554.80603	87.56521
Uruguay	740.02887	0.03240	575.40320	164.62569
Ireland	552.30054	0.03339	592.94531	-40.64476
Hungary	635.12610	0.03363	597.09674	38.02934
Italy	795.93829	0.03825	679.17511	116.76319
Japan	675.71954	0.04230	751.17371	-75.45415
Spain	930.52264	0.04348	772.12329	158.39937
United Kingdom	540.70721	0.04598	816.38110	-275.67386
Netherlands	588.25000	0.04924	874.35968	-286.10968
Austria	638.28845	0.05341	948.30255	-310.01407
Belgium	725.77979	0.05386	956.41565	-230.63588
Germany	591.41577	0.05422	962.74469	-371.32892
France	734.84668	0.05427	963.66577	-228.81906
Denmark	637.92981	0.05637	1001.01965	-363.08987
Luxembourg	767.55859	0.05700	1012.09344	-244.53487
United States	658.25000	0.07196	1277.85474	-619.60468

To calculate the volume-of-trade statistic, repeat for all goods.

Sum the positive (or negative) values of (D) over all goods and and all countries to get total world imports.

Sum the values of (C) or (A) over all goods and all countries to get total world consumption (endowments).

Divide the value of imports by the value of consumption to get trade as a percentage of consumption.

13.4% = Imports as a % of Consumption

Note: Rounding error accounts for the fact that (D) is not exactly equal to (A)-(C).

TABLE 7

AN EXAMPLE OF THE VOLUME-OF-TRADE COUNTERFACTUAL CALCUATIONS FOR THE FOOD SECTOR (FITTED CONSUMPTION DATA)

COUNTRY	(A) CONSUMPTION OF FOOD PER CAPITA (FITTED)	(B) "SHARE OF WORLD INCOME"	(C) IMPLIED ENDOWMENT OF FOOD PER CAPITA (B)X(SUM(A))	(D) IMPORTS OF FOOD PER CAPITA (A)-(C)
Malawi	318.86282	0.00398	67.60413	251.25868
India	325.50232	0.00492	83.49298	242.00934
Kenya	328.15912	0.00529	89.85088	238.30824
Zambia	333.34830	0.00603	102.26902	231.07927
Pakistan	336.05496	0.00641	108.74628	227.30869
Sri Lanka	343.30298	0.00743	126.09138	217.21159
Philippines	361.90430	0.01005	170.60588	191.29842
Thailand	362.45767	0.01013	171.93011	190.52756
Malaysia	387.13290	0.01361	230.97995	156.15295
Korea	396.03958	0.01486	252.29434	143.74524
Brazil	415.98233	0.01768	300.01901	115.96333
Columbia	421.36700	0.01843	312.90497	108.46204
Syria	423.92291	0.01880	319.02145	104.90144
Jamaica	427.65591	0.01932	327.95483	99.70107
Iran	428.94751	0.01950	331.04575	97.90177
Romania	438.81406	0.02089	354.65720	84.15686
Yugoslavia	466.94101	0.02486	421.96722	44.97377
Mexico	480.66080	0.02679	454.79980	25.86099
Poland	512.22540	0.03124	530.33643	-18.11105
Uruguay	520.45276	0.03240	550.02521	-29.57244
Ireland	527.45978	0.03339	566.79364	-39.33384
Hungary	529.11804	0.03363	570.76196	-41.64394
Italy	561.90350	0.03825	649.22028	-87.31678
Japan	590.66272	0.04230	718.04340	-127.38068
Spain	599.03088	0.04348	738.06903	-139.03813
United Kingdom	616.70923	0.04598	780.37482	-163.66560
Netherlands	639.86829	0.04924	835.79633	-195.92801
Austria	669.40411	0.05341	906.47791	-237.07381
Belgium	672.64484	0.05386	914.23322	-241.58839
Germany	675.17291	0.05422	920.28314	-245.11020
France	675.54083	0.05427	921.16357	-245.62273
Denmark	690.46155	0.05637	956.87000	-266.40845
Luxembourg	694.88483	0.05700	967.45538	-272.57056
United States	801.04083	0.07196	1221.49524	-420.45444

To calculate the volume-of-trade statistic, repeat for all goods.
Sum the positive (or negative) values of (D) over all goods and and all countries to get total world imports.
Sum the values of (C) or (A) over all goods and all countries to get total world consumption (endowments).
Divide the value of imports by the value of consumption to get trade as a percentage of consumption.

<u>14.4% = Imports as a % of Consumption</u>

Note: Rounding error accounts for the fact that (D) is not exactly equal to (A)-(C).

We then repeat this procedure to get what we believe to be the most relevant statistic for the purposes of this paper. We use the fitted values of consumption instead of the actual values in order to eliminate trade based on taste and price differences. This does not of course mean that the calculated volume of trade will now be less since the latter causes of trade may either reinforce or offset trade caused by differences in per capita income. In our case the volume of trade actually rises to 14.4% of world consumption. We regard this result to be very significant in economic terms, but a discussion of this is temporarily posponed until the next section.

Table 7 duplicates the example of Table 6 for the food sector. Column (A) now gives fitted consumption from the LES estimates in Table 2 at U.S. prices for all countries. Shares remain the same. Column (D) shows that imports fall as per capita income rises due to the fact that the income elasticity of demand for food is less than one (bottom of Table 2). Between Mexico and Poland lies the average per capita income in the sample that divides the importers from the exporters. This dividing point is the same for all goods (since it is related to total income, not the good in question). Goods with income elasticities of demand less than one will have plus entries for Malawi through Mexico (as in the case for the food example) and negative entries for Poland through the U.S. The opposite occurs for goods with income elasticities of demand greater than one.

5. IMPLICATIONS AND APPLICATIONS

Earlier we addressed the issue of the statistical significance of our results and concluded that there is a strong case for rejecting the hypothesis of homogeneity. But this does not of course imply that the deviations from homotheticity are significant in economic terms. The volume-of-trade exercise of the previous section was designed to get at exactly this issue.

We regard our result of a 14.4% share of trade in the case of fitted demand to be very significant in economic terms. That is, we conclude that differences in demand due to differences in per capita income probably do contribute in a significant way to the overall volume and direction of trade. But since this summary statistic is an unusual measure of "economic significance", we have constructed a simple two-good two-person (country) example to help illustrate the point.

Table 8 and Figure 3 present the example which generates a volume-of-trade statistic of 14.4%, thus matching our earlier result. The total endowment of ten units of each good is divided unevenly so that person B has just over 3.5 times the income of person A. This almost exactly matches the difference that is obtained from the full data if the incomes of the top 17 and bottom 17 countries are each averaged together to generate a two-country sample. Marginal propensities are 0.9 and 0.1 for the two goods, which matches almost exactly what we would get by collapsing the 11 good data into non-food and food items. The difference is that the minimum consumption requirement for C_2 ("food") in Table 8 and Figure 3 is much higher than what we would get by collapsing the full LES into a two-good example. The reason is that the latter exercise would net out a lot of trade by aggregating together items with high and low income elasticities of demand.

Equilibrium consumption bundles are plotted in Figure 3 and linked to the endowment points by the equilibrium price ratio of 1.8. Although the point is hardly scientific, we believe that the deviation from homotheticity shown in Figure 3 is highly significant. Visually, the income-consumption path lies "far" from the diagonal. If these less-than-rigorous statements are taken to be sensible if not definitive, then we should also conclude that the

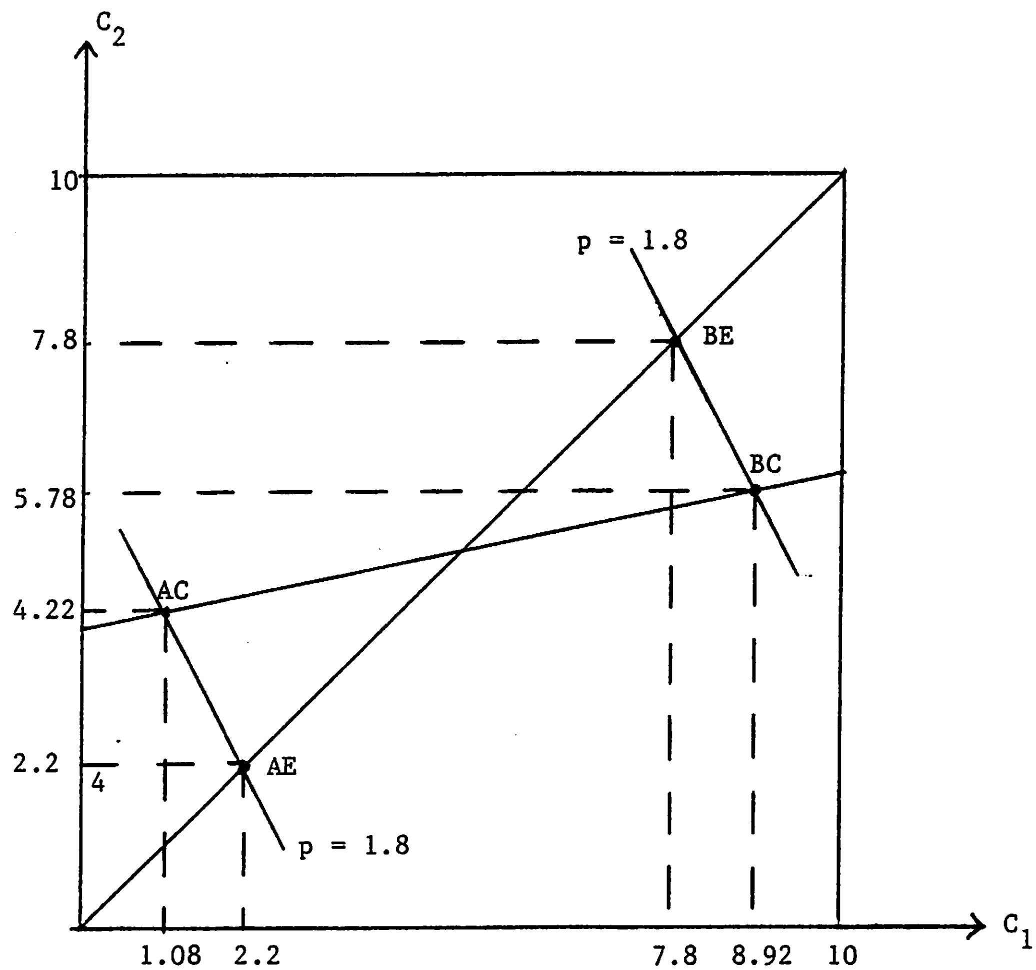
TABLE 8

A TWO-PERSON, TWO-GOOD EXAMPLE OF THE VOLUME-OF-TRADE EFFECT

Total Endowments	Good 1 (C_1) = 10, Good 2 (C_2) = 10
Preferences	$\bar{C}_2 = 4$, $\bar{C}_1 = 0$; $\beta_2 = .1$, $\beta_1 = .9$
Individual endowments	Person A ($C_1 = C_2 = 2.2$), Person B ($C_1 = C_2 = 7.8$)
Equilibrium price ratio	$p_1/p_2 = 1.8$
Income elasticities (at mean I, C_1, C_2)	Income elas for C_2: 0.28; Income elas for C_1: 2.52
Individual incomes (in terms of C_2)	$I_a = 6.16$, $I_b = 21.84$, $I_a + I_b = 28$, $I_b/I_a = 3.5$
Individual consumption	A: $C_2 = 4.216$ $C_1 = 1.080$; B: $C_2 = 5.784$ $C_1 = 8.920$
Individual imports	A: $C_2 = 2.016$ B: $(p_1/p_2)C_1 = 2.016$
Imports/Consumption	14.4% = (4.032)/(28)

FIGURE 3

A numerical/graphical example that generates a volume-of-trade statistic of 14.4% (see Table 8)



AC: A's consumption bundle
AE: A's endowment bundle
BC: B's consumption bundle
BE: B's endowment bundle

Note: Some numbers in the diagram are rounded. See Table 8 for exact numbers.

measured deviation from homotheticity in the full LES estimation is significant in economic terms given that both generate the 14.4% trade statistic.

These results have in turn a number of interesting applications. One is to the well-known if not well-understood or well-appreciated model of Linder (1961). Linder suggested that manufactured goods are created by domestic entreprenuers in response to perceived domestic demands. These demands are in turn closely related to the level of domestic per capita income. When new products are introduced, the entreprenuers will also export those products to countries which exhibit similar demands, meaning similar per capita incomes. Trade in manufactured goods is thus most intense among countries with similar per capita incomes. This theory contains many elements which are far beyond the scope of this paper. But the above results indicate support for the notion that demands are related to per capital income and thus countries with similar per capita incomes will exhibit similar demand patterns.

The results also relate to the hypothesis associated with Prebisch (1964) and Singer (1950). This hypothesis states that the labor-abundant "South" produces commodities with low income elasticities of demand while the high income "North" produces the high-income-elasticity commodities. As world per capita income grows, the terms of trade then systematically turn against the South. As in the case of the Linder model, there are many controversial elements of this theory, especially the use of the theory to attempt to justify import-substituting industrialization (which does not follow even if the basic theory is correct). The results here do not address these elements, but do suggest that biased changes in the terms of trade due to growth should not be dismissed as an irrelevant economic issue.

A third application is to note that the LES demand estimates can be integrated with Leamer (1984) to show more formally in exactly what sense per capita income forms a basis for trade. Assume that commodity prices are the same everywhere and that all of the various assumptions needed for factor price equalization hold. Pick commodity units so that all prices are one. Using our linear expenditure system, the total consumption vector C for a country is given by

(7) $C = \alpha L + \beta I.$

where L is population and I total income. α and β have the same interpretation as above except that they now depend on the choice of units or alternatively on the price normalization (i.e., prices are now hidden in α and β). α and β are vectors while L and I are scalars. Let A refer to the matrix that maps the vector of endowments into the vector of outputs. This mapping is assumed to be the same everywhere by virtue of factor price equalization (discussed at length by Leamer). The value of production, denoted X, for a country is thus

(8) $X = AV$

where V is the endowment vector. By the assumption that A is the same in all countries, the production relations in (8) can be aggregated for all countries. Let the subscript w refer to the total world level of a variable. The requirement that total world consumption equals total world output is given by

(9) $\alpha L_w + \beta I_w = AV_w$ or

(10) $\beta = (AV_w - \alpha L_w)/I_w$

A country's net export vector is given by

(11) $T = AV - C = AV - \alpha L - \beta I$

Substituting for β from (10), we have

(12) $T = AV - \alpha L - (AV_w - \alpha L)I/I_w$

$= A(V - sV_w) - \alpha(L - sL_w)$

where $s = I/I_W$ is the country's share of total world income. The two terms in (12), which are more or less the same as those suggested by Leamer, correspond to the two separate bases for trade: The first is Heckscher-Ohlin trade while the second is trade based on differences in per-capita income. To elaborate, the first term is trade due to differences in factor endowments given identical, homothetic demand across countries. A country's production is AV. If tastes are identical and homothetic, then each country's consumption bundle is a proportional share of total world production, where the share is the country's share of total income. Thus under this demand postulate, a country's consumption is simply AsV_W.

The second term in (12) is trade due to non-homotheticity and to international differences in per capita income. Note that if demand is homothetic then α is the zero vector and the last term disappears. Secondly, note that if a country has the same share of world labor as it has of world income, $L = sL_W$, then the last term is zero. But this is of course just another way of saying that the country has a per-capita income equal to the world per-capita income, in which case we noted above in connection with Figure 2 that there will be no demand-induced trade by that country.

In summary, equation (12) breaks trade down into two sources or bases. Leamer estimates the matrix A with the second term suppressed. With our estimates of α from above, A could be reestimated in order to sort out the separate contributions of factor endowments and per capita income. Much work is needed, however, in order to arrive at a compatible commodity classification for trade and consumption vectors (i.e., the "goods" that are traded in Leamer's data are quite different aggregates from the "goods" that are consumed in the above empirical analysis).

Equation (12) also sheds some light on the issue of so-called "Leontief paradox" results (Leontief (1953, 1956)). These results involve countries apparently exporting goods using intensively the countries' scarce factors. The relevance of the present paper to this problem can be illustrated by considering the two-good version of the equations in (12). Suppose that good 1 is relatively intensive in factor 1 and that the country in question is relatively well endowed with factor 1. In this case, the first element of the vector $A(V - sV_w)$ is positive while the second element is negative. If this was the only term, the country would indeed be exporting the good using intensively the country's abundant factor. Suppose that factor 1 is labor and that good 1 has a high minimum consumption requirement while good 2 has no minimum consumption requirement. The first element of the vector $\alpha(L - sL_w)$ is then negative while the second element is positive. The per capita income effect thus works in the opposite direction from the Heckscher-Ohlin effect. There is nothing to suggest that the former effect cannot dominate so that the country is observed to import the good using intensively the abundant factor. If food is labor intensive, for example, it is perfectly consistent with our empirical results to find very poor countries importing food.

A final application of the results has to do with the issue of "North-South" versus "East-West" trade. There has been discussion in the literature about the apparently large volume of trade among the industrialized countries (East-West trade) relative to North-South Trade. Since the former countries have very similar factor endowments, this trade pattern is seemingly at odds with factor-proportions theory. Markusen (1985) shows that adding the LES formulation from this paper to a monopolistic competition model offers one explanation of this trading pattern. Suppose that the labor abundant South produces labor-intensive homogenous goods which it trades for capital-intensive differentiated manufactured goods from the North. Assume further that the labor intensive goods have high minimum consumption requirements (e.g., food) as in the above example. Then the South specializes in both consuming and producing the same set of goods and trade is accordingly reduced below what would be predicted by the Heckscher-Ohlin model.

The industrialized countries are also relatively specialized in both consuming and producing the same set of goods. But if these are differentiated manufacturing goods, then each good is sold to both domestic and some foreign consumers such that these goods are "cross-hauled" among the industrialized countries. While net trade flows may be small, the gross flows which are the subject of debate are accordingly large. In the model, increases in the degree of non-homogeneity lead to reductions in North-South trade, but to increases in East-West trade.

REFERENCES

Deaton, Angus and John Muellbauer (1980), Economics and Consumer Behavior, Cambridge: Cambridge University Press.

Harvey, A. C. (1981), The Economic Analysis of Time Series, Oxford: Philip Allan

Kravis, Irving, Alan Heston, and Robert Summers (1982), World Product and Income: International Comparisons of Real Gross Product, published for the World Bank by Johns Hopkins University Press.

Leamer, Edward (1984), Sources of International Comparative Advantage, Cambridge Massachusetts, MIT Press.

Leontief, W. W. (1953), "Domestic Production and Foreign Trade: The American Capital Position Re-examined," Proceedings of the American Philosophical Society 97, 332-49.

Leontief, W. W. (1956), "Factor Proportions and the Structure of American Trade: Further Theoretical and Empirical Analysis," Review of Economics and Statistics 38, 386-407.

Linder, Staffan (1961), An Essay on Trade and Transformation, Stockholm: Almqvist and Wiksell.

Markusen, James (1985), "Explaining the Volume of Trade: An Eclectic Approach Involving Factor Endowments, Scale Economies, and Non-Homothetic Demand," University of Western Ontario Working Paper.

Prebisch, Raul (1964), Towards a New Trade Policy for Development, Report by the Secretary General of UNCTAD, New York: United Nations.

Singer, Hans (1950), "The Distribution of Gains between Investing and Borrowing Countries," American Economic Review.

8401C Harrison, Glenn W. and Manning, Richard. BEST APPROXIMATE AGGREGATION OF INPUT-OUTPUT SYSTEMS.

8402C Parkin, Michael. CORE INFLATION: A REVIEW ESSAY.

8403C Blomqvist, Åke, and McMahon, Gary. SIMULATING COMMERICAL POLICY IN A SMALL, OPEN DUAL ECONOMY WITH URBAN UNEMPLOYMENT: A GENERAL EQUILIBRIUM APPROACH.

8404C Wonnacott, Ronald. THE THEORY OF TRADE DISCRIMINATION: THE MIRROR IMAGE OF VINERIAN PREFERENCE THEORY?

8405C Whalley, John. IMPACTS OF A 50% TARIFF REDUCTION IN AN EIGHT-REGION GLOBAL TRADE MODEL.

8406C Harrison, Glenn W. A GENERAL EQUILIBRIUM ANALYSIS OF TARIFF REDUCTIONS.

8407C Horstmann, Ignatius and Markusen, James R. STRATEGIC INVESTMENTS AND THE DEVELOPMENT OF MULTINATIONALS.

8408C Gregory, Allan W. and McCurdy, Thomas H. TESTING THE UNBIASEDNESS HYPOTHESIS IN THE FORWARD FOREIGN EXCHANGE MARKET: A SPECIFICATION ANALYSIS.

8409C Jones, Ronald W. and Kierzkowski, Henryk. NEIGHBORHOOD PRODUCTION STRUCTURES WITH APPLICATIONS TO THE THEORY OF INTERNATIONAL TRADE.

8410C Weller, Paul and Yano, Makoto. THE ROLE OF FUTURES MARKETS IN INTERNATIONAL TRADE: A GENERAL EQUILIBRIUM APPROACH.

8411C Brecher, Richard A. and Bhagwati, Jagdish N. VOLUNTARY EXPORT RESTRICTIONS VERSUS IMPORT RESTRICTIONS: A WELFARE-THEORETIC COMPARISON.

8412C Ethier, Wilfred J. ILLEGAL IMMIGRATION.

8413C Eaton, Jonathon and Gene M. Grossman. OPTIMAL TRADE AND INDUSTRIAL POLICY UNDER OLIGOPOLY.

8414C Wooton, Ian. PREFERENTIAL TRADING AGREEMENTS - A 3xn MODEL.

8415C Parkin, Michael. DISCRIMINATING BETWEEN KEYNESIAN AND CLASSICAL THEORIES OF THE BUSINESS CYCLE: JAPAN 1967-1982

8416C Deardorff, Alan V. FIRless FIRwoes: HOW PREFERENCES CAN INTERFERE WITH THE THEOREMS OF INTERNATIONAL TRADE.

8417C Greenwood, Jeremy. NONTRADED GOODS, THE TRADE BALANCE, AND THE BALANCE OF PAYMENTS.

8418C Blomqvist, Ake and Sharif Mohammad. CONTROLS, CORRUPTION, AND COMPETITIVE RENT-SEEKING IN LDCs.

8419C Grossman, Herschel I. POLICY, RATIONAL EXPECTATIONS, AND POSITIVE ECONOMIC ANALYSIS.

8420C Garber, Peter M. and Robert G. King. DEEP STRUCTURAL EXCAVATION? A CRITIQUE OF EULER EQUATION METHODS.

8421C Barro, Robert J. THE BEHAVIOR OF U.S. DEFICITS.

8422C Persson, Torsten and Lars E.O. Svensson. INTERNATIONAL BORROWING AND TIME-CONSISTENT FISCAL POLICY.

8423C Obstfeld Maurice. CAPITAL CONTROLS, THE DUAL EXCHANGE RATE, AND DEVALUATION.

8424C Kuhn, Peter. UNION PRODUCTIVITY EFFECTS AND ECONOMIC EFFICIENCY.

8425C Hamilton, Bob and John Whalley. TAX TREATMENT OF HOUSING IN A DYNAMIC SEQUENCED GENERAL EQUILIBRIUM MODEL.

8426C Hamilton, Bob, Sharif Mohammad, and John Whalley. RENT SEEKING AND THE NORTH-SOUTH TERMS OF TRADE.

8427C Adams, Charles and Jeremy Greenwood. DUAL EXCHANGE RATE SYSTEMS AND CAPITAL CONTROLS: AN INVESTIGATION.

8428 Loh, Choon Cheong and Michael R. Veall. A NOTE ON SOCIAL SECURITY AND PRIVATE SAVINGS IN SINGAPORE.

8429 Whalley, John. REGRESSION OR PROGRESSION: THE TAXING QUESTION OF INCIDENCE ANALYSIS.

8430 Kuhn, Peter. WAGES, EFFORT, AND INCENTIVE-COMPATIBILITY IN LIFE-CYCLE EMPLOYMENT CONTRACTS.

8431 Greenwood, Jeremy and Kent P. Kimbrough. AN INVESTIGATION IN THE THEORY OF FOREIGN EXCHANGE CONTROLS.

8432 Greenwood, Jeremy and Kent P. Kimbrough. CAPITAL CONTROLS AND THE INTERNATIONAL TRANSMISSION OF FISCAL POLICY.

8433 Nguyen, Trien Trien and John Whalley. EQUILIBRIUM UNDER PRICE CONTROLS WITH ENDOGENOUS TRANSACTIONS COSTS.

8434 Adams, Charles and Russell S. Boyer. EFFICIENCY AND A SIMPLE MODEL OF EXCHANGE RATE DETERMINATION.

8435 Kuhn, Peter. UNIONS, ENTREPRENEURSHIP, AND EFFICIENCY.

8436 Hercowitz, Zvi and Efraim Sadka. ON OPTIMAL CURRENCY SUBSTITUTION POLICY AND PUBLIC FINANCE.

8437 Lenjosek, Gordon and John Whalley. POLICY EVALUATION IN A SMALL OPEN PRICE TAKING ECONOMY: CANADIAN ENERGY POLICIES.

8438 Aschauer, David and Jeremy Greenwood. MACROECONOMIC EFFECTS OF FISCAL POLICY.

8439C Hercowitz, Zvi. ON THE DETERMINATION OF THE EXTERNAL DEBT: THE CASE OF ISRAEL.

8440C Stern, Robert M. GLOBAL DIMENSIONS AND DETERMINANTS OF INTERNATIONAL TRADE AND INVESTMENT IN SERVICES.

8441C Deardorff, Alan V. COMPARATIVE ADVANTAGE AND INTERNATIONAL TRADE AND INVESTMENT IN SERVICES.

8442C Daly, Donald J. TECHNOLOGY TRANSFER AND CANADA'S COMPETITIVE PERFORMANCE.

8443C Grey, Rodney de C. NEGOTIATING ABOUT TRADE AND INVESTMENT IN SERVICES.

8444C Grossman, Gene M. and Carl Shapiro. NORMATIVE ISSUES RAISED BY INTERNATIONAL TRADE IN TECHNOLOGY SERVICES.

8445C Chant, John F. THE CANADIAN TREATMENT OF FOREIGN BANKS: A CASE STUDY IN THE WORKINGS OF THE NATIONAL TREATMENT APPROACH.

8446C Aronson, Jonathan D. and Peter F. Cowhey. COMPUTER, DATA PROCESSING, AND COMMUNICATION SERVICES.

8447C Feketekuty, Geza. NEGOTIATING STRATEGIES FOR LIBERALIZING TRADE AND INVESTMENT IN SERVICES.

8448C Harrison, Glenn, W. and E.E. Rutstrom. THE EFFECT OF MANUFACTURING SECTOR PROTECTION ON ASEAN AND AUSTRALIA: A GENERAL EQUILIBRIUM ANALYSIS.

8501C Greenwood, Jeremy and Kent P. Kimbrough. FOREIGN EXCHANGE CONTROLS IN A BLACK MARKET ECONOMY.

8502C Horstmann, Ignatius and James R. Markusen. UP YOUR AVERAGE COST CURVE: INEFFICIENT ENTRY AND THE NEW PROTECTIONISM.

8503C Gregory, Allan W. TESTING INTEREST RATE PARITY AND RATIONAL EXPECTATIONS FOR CANADA AND THE UNITED STATES.

8504C Kuhn, Peter and Ian Wooton. INTERNATIONAL FACTOR MOVEMENTS IN THE PRESENCE OF A FIXED FACTOR.

8505C Wong, Kar-yiu. GAINS FROM GOODS TRADE AND FACTOR MOBILITY.

8506C Weller, Paul and Makoto Yano. FUTURES MARKETS, REAL INCOME, AND SPOT PRICE VARIABILITY: A GENERAL EQUILIBRIUM APPROACH.

8507C Diewert, W.E. THE EFFECTS OF AN INNOVATION: A TRADE THEORY APPROACH.

8508C Ethier, Wilfred J. FOREIGN DIRECT INVESTMENT AND THE MULTINATIONAL FIRM.

8509C Dinopoulos, Elias. INSIDE THE BLACK BOX: (IN)TANGIBLE ASSETS, INTRA-INDUSTRY INVESTMENT AND TRADE.

8510C Jones, Richard, John Whalley, and Randall Wigle. REGIONAL IMPACTS OF TARIFFS IN CANADA: PRELIMINARY RESULTS FROM A SMALL DIMENSIONAL NUMERICAL GENERAL EQUILIBRIUM MODEL.

8511C Whalley, John. HIDDEN CHALLENGES IN RECENT APPLIED GENERAL EQUILIBRIUM EXERCISES.

8512C Smith, Bruce. SOME COLONIAL EVIDENCE ON TWO THEORIES OF MONEY: MARYLAND AND THE CAROLINAS.

8513C Grossman, S.J., A. Melino, and R.J. Shiller. ESTIMATING THE CONTINUOUS TIME CONSUMPTION BASED ASSET PRICING MODEL.

8514C Romer, Paul R. TAX EFFECTS AND TRANSACTION COSTS FOR SHORT TERM MARKET DISCOUNT BONDS.

8515C McCallum, Bennett T. ON CONSEQUENCES AND CRITICISMS OF MONETARY TARGETING.

8516C Dinopoulos, Elias and Ian Wooton. A NORTH-SOUTH MODEL OF INTERNATIONAL JUSTICE.

8517C Huffman, Gregory W. A DYNAMIC EQUILIBRIUM MODEL OF ASSET PRICES AND TRANSACTION VOLUME.

8518C Huffman, Gregory W. AN ALTERNATIVE VIEW OF OPTIMAL SEIGNIORAGE.

8519C Huffman, Gregory W. ASSET PRICING WITH HETERGENEOUS ASSETS.

8520C Hercowitz, Zvi. THE REAL INTEREST RATE AND AGGREGATE SUPPLY.

8521C Davies, James and Michael Hoy. COMPARING INCOME DISTRIBUTIONS UNDER AVERSION TO DOWNSIDE INEQUALITY.

8522C Nguyen, Trien T. and John Whalley. COEXISTENCE OF EQUILIBRIA ON BLACK AND WHITE MARKETS.

8523C Clarete, Ramon and John Whalley. INTERACTIONS BETWEEN TRADE POLICIES AND DOMESTIC DISTORTIONS: THE PHILIPPINE CASE.

8524C Hamilton, Bob, Sharif Mohammad, and John Whalley. APPLIED GENERAL EQUILIBRIUM ANALYSIS AND PERSPECTIVES ON GROWTH PERFORMANCE.

8525C Huffman, Gregory W. THE LAGGED EFFECTS OF POLICY ON THE PRICE LEVEL.

8526C Laidler, David. FISCAL DEFICITS AND INTERNATIONAL MONETARY INSTITUTIONS.

8527C Goodfriend, Marvin. MONETARY MYSTIQUE: SECRECY AND CENTRAL BANKING.

8528C Nguyen, Trien T. and John Whalley. GENERAL EQUILIBRIUM ANALYSIS OF PRICE CONTROLS A TWO-SECTOR COMPUTATIONAL APPROACH.

8529C Heckman, James J. and V. Joseph Hotz. AN INVESTIGATION OF THE LABOR MARKET EARNINGS OF PANAMANIAN MALES: EVALUATING SOURCES OF INEQUALITY.

8530C Greenwood, Jeremy and Gregory W. Huffman. A DYNAMIC EQUILIBRIUM MODEL OF INFLATION AND UNEMPLOYMENT.

8531C Freeman, Scott. INSIDE MONEY, MONETARY CONTRACTIONS, AND WELFARE.

8532C Paderanga, Cayetano Jr. and Ian Wooton. A POSITIVE VIEW OF INFANT INDUSTRIES.

8533C St-Hilaire, France and John Whalley. A MICROCONSISTENT DATA SET FOR CANADA FOR USE IN REGIONAL GENERAL EQUILIBRIUM POLICY ANALYSIS.

8534C Whalley, John. OPERATIONALIZING WALRAS: EXPERIENCE WITH RECENT APPLIED GENERAL EQUILIBRIUM TAX MODELS.

8535C Melvin, James R. THE GENERAL NON-EQUIVALENCE OF TARIFFS AND IMPORT QUOTAS.

<u>1986</u>

8601C Greenwood, Jeremy and R. Preston McAfee. EXTERNALITIES AND ASYMMETRIC INFORMATION.

8602C Dinopoulos, Elias and Mordechai E. Kreinin. IMPORT QUOTAS AND VERS: A COMPARATIVE ANALYSIS IN A THREE-COUNTRY FRAMEWORK.

8603C Clarete, Ramon and John Whalley. COMPARING THE MARGINAL WELFARE COSTS OF COMMODITY AND TRADE TAXES.

8604C Wigle, Randy. CANADIAN TRADE LIBERALIZATION: SCALE ECONOMIES IN A GLOBAL CONTEXT.

8605C Parkin, Michael. DOMESTIC MONETARY INSTITUTIONS AND FISCAL DEFICITS.

8606C Dinopoulos, Elias and Ian Wooton. INTERNATIONAL TRADE AND THE ACQUISITION OF SKILLS.

8607C Kawasaki, Seiichi and John McMillan. THE DESIGN OF CONTRACTS: EVIDENCE FROM JAPANESE SUBCONTRACTING.

8608C Williamson, Stephen D. LIQUIDITY, BANKING, AND BANK FAILURES.

8609C Grossman, Gene M. and Carl Shapiro. COUNTERFEIT-PRODUCT TRADE.

8610C Deardorff, Alan V. WHY DO GOVERNMENTS PREFER NONTARIFF BARRIERS?

8611C Horstmann, Ignatius and James R. Markusen. LICENSING VERSUS DIRECT INVESTMENT: A MODEL OF INTERNALIZATION BY THE MULTINATIONAL ENTERPRISE.

8612C Thursby, Jerry G. and Marie C. Thursby. BILATERAL TRADE FLOWS, THE LINDER HYPOTHESIS, AND EXCHANGE RISK.

8613C Clarete, Ramon and John Whalley. EQUILIBRIUM IN THE PRESENCE OF FOREIGN EXCHANGE PREMIA.

8614C Wooton, Ian. TOWARDS A COMMON MARKET: FACTOR MOBILITY IN A CUSTOMS UNION.

8615C St-Hilaire, France and John Whalley. SOME ESTIMATES OF TRADE FLOWS IN BANKING SERVICES.

8616C Evenson, Robert E. and Cayetano Paderanga Jr. RURAL LABOUR MARKETS, TRANSACTION COST AND FERTILITY.

8617C Fried, Joel and Peter Howitt. FISCAL DEFICITS, INTERNATIONAL TRADE AND WELFARE.

8618C Trela, Irene, John Whalley, and Randy Wigle. INTERNATIONAL TRADE IN AGRICULTURE: DOMESTIC POLICIES, TRADE CONFLICTS, AND NEGOTIATING OPTIONS.

8619C Markusen, James R. and Anthony J. Venables. TRADE POLICY WITH INCREASING RETURNS AND IMPERFECT COMPETITION: CONTRADICTORY RESULTS FROM COMPETING ASSUMPTIONS.

8620C Hunter, Linda and James R. Markusen. PER-CAPITA INCOME AS A DETERMINANT OF TRADE.