Structural Determinants of Real Exchange Rates and National Price Levels: Some Empirical Evidence

By JEFFREY H. BERGSTRAND*

Contrary to the long-held notion of purchasing power parity (PPP), economists have found systematic evidence that the general level of prices across countries at a point in time varies dramatically. Irving B. Kravis, Alan W. Heston, and Robert Summers (1982), for example, report that some countries' national price levels are no more than *one-third* the U.S. price level. Extensions of this work show that such departures from PPP have persisted for decades.

Recently, efforts have been made to explain systematically these persistent, or structural, departures from PPP. Pioneering work by Kravis and Robert E. Lipsey (1983, 1987, 1988) has demonstrated that a positive correlation between the price level and (real) per capita gross domestic product is robust across numerous cross-sectional specifications. For instance, using data from Kravis et al. (1982 table 6-12), 87 percent of the variation in national price levels (PL) of 21 countries[1] in 1975 is explained by per capita GDP (y) and a constant:

$$\ln(\mathrm{PL}) = \underset{(12.25)}{2.20} + \underset{(11.72)}{0.56}\ln y \tag{1}$$

($\bar{R}^2 = 0.87$, RMSE $= 0.18$; t statistics in parentheses).

Although Christopher Clague (1986) showed that other "structural" characteristics (such as the trade balance, tourism receipts' share of GDP, and minerals' share of GDP) have significant explanatory power when also included, *why* per capita GDP has such a robust empirical correlation to the price level and *what* economic factor(s) it represents have not yet been determined. In the study of structural determinants of the price level, the two predominant competing theories for per capita GDP's role are the productivity-differentials (or Ricardian) model usually attributed to Bela Balassa (1964) and Paul A. Samuelson (1964) and the relative-factor-endowments (or Heckscher-Ohlin) model discussed in Jagdish N. Bhagwati (1984).

The purpose of this study is to distinguish empirically these two competing supply-oriented hypotheses, along with a possible third *demand*-oriented hypothesis that has received virtually no attention. This third hypothesis suggests that, assuming nonhomothetic tastes,[2] price levels are higher in countries with higher per capita GDP's because nontraded services are luxuries in consumption while traded commodities are necessities. The empirical evidence in the second section suggests that the null hypothesis that per capita income has no effect on the national price level via this demand channel is rejected.

*Department of Finance and Business Economics, College of Business Administration, University of Notre Dame, Notre Dame, IN 46556. I am grateful to Ron Balvers, Tom Bundt, Jim Hartigan, Ron Jones, Norman Miller, J. David Richardson, Rich Sheehan, and two anonymous referees for helpful comments on an earlier draft, which was presented at the Western Economics Association annual meeting, June 1989, in Lake Tahoe, Nevada. Financial support from the Center for Research in Business at the University of Notre Dame, with funding from the Transamerica Fund, is gratefully acknowledged.

[1]The 21 countries are India, Sri Lanka, Thailand, the Philippines, Korea, Columbia, Jamaica, Brazil, Yugoslavia, Ireland, Italy, Spain, the United Kingdom, Japan, Austria, the Netherlands, Belgium, France, Denmark, Germany, and the United States. These countries were selected for constraints that will become apparent in Section II.

[2]Nonhomothetic tastes imply that the income-expansion path through the indifference curves of the representative consumer is not a straight line through the origin, generating an income elasticity of demand greater (less) than 1 for the nontraded service (traded commodity).

I. Theoretical Issues

> Across countries, price levels are expected to be positively associated with [real per capita] income because prices of nontradeables [mainly services] are higher relative to prices of tradeables [mainly commodities] in rich countries than in poor countries.
> [Kravis and Lipsey, 1988 p. 474][3]

Consider the national price level as decomposable into (nontraded) services' prices and (traded) commodities' prices. According to the productivity-differentials model, rich countries are believed to have absolute productivity advantages in both services and commodities, but a relative productivity advantage in commodities. Consequently, the relative price of services to commodities (henceforth, the "relative price level" or "real exchange rate") will be higher in countries with larger per capita incomes. Since commodity arbitrage will tend to equilibrate commodities' prices across countries, the national price level will tend to be higher in rich countries, since their price of services relative to commodities is higher. One would then expect to find a similar high correlation between the relative price level (p) and per capita GDP across countries. Indeed, using the same data set as for regression equation (1), 85 percent of the variation in relative prices is explained by per capita income and a constant:

$$(2)\quad \ln p = \underset{(12.48)}{2.20} + \underset{(10.58)}{0.50} \ln y$$

($\bar{R}^2 = 0.85$, RMSE $= 0.17$; t statistics in parentheses).

The predominant alternative explanation to productivity differentials involves relative factor endowments. In the two-good, two-factor, relative-factor-endowments model, services (commodities) are assumed to be relatively labor-intensive (capital-intensive) in production. Relatively capital-abundant rich countries will have a comparative advantage in producing commodities, so that the price of services relative to commodities, and thus the national price level, will be higher in countries with larger per capita income.

However, little attention has been devoted to a Linder-type hypothesis as an alternative demand-side explanation for why per capita GDP is positively correlated with the real exchange rate and national price level. Although Rudiger Dornbusch (1988) and J. Peter Neary (1988) noted that shifts in tastes as well as in technologies and relative factor endowments can change the real exchange rate, no one has attempted to link explicitly differences in tastes across countries with differences in their per capita GDP's (as suggested in Linder [1961]) and differences in their real exchange rates. To illustrate these linkages, consider the following model (see Neary [1988] for a more general discussion using trade-expenditure functions).

A. *Demand*

Staffan Burenstam Linder (1961 p. 94) suggested that a "whole array of factors influences the demand structure of a country," but that per capita income was likely to be the "most important single factor." He argued:

> At higher [real per capita] incomes, products of different kinds, although filling the same basic needs, are likely to replace less sophisticated types of products; furthermore, products filling new needs are added.... But the more we divide total production into subgroups, the greater will be the variations in income elasticity. [pp. 94–5]

I formalize the Linder claim that per capita income has a dominant influence on the structure of demand by assuming the following nonhomothetic, nested Cobb-Douglas-Stone-Geary utility function for the

[3]Bracketed terms added. In the Kravis et al. (1982) data, the empirical distinction between nontradeables and services and between tradeables and commodities is fairly minor and rests entirely upon the treatment of construction. Tradeables consist of all commodities except construction; nontradeables consist of all services plus construction (see Kravis et al., 1982 p. 193). Consequently, reference here will be made to nontraded services and traded commodities.

representative consumer-worker:

$$(3) \quad u = (x_T - \bar{x}_T)^{\delta}(x_N - \bar{x}_N)^{1-\delta} \qquad 0 < \delta < 1$$

where x_T (x_N) is the amount consumed of the traded commodity (nontraded service) and $\bar{x}_T$ ($\bar{x}_N$) is an exogenous minimum-consumption requirement that exists for the traded commodity (nontraded service), common to the Stone-Geary utility function. Ready examples of traded commodities and nontraded services that would have minimum per capita consumption requirements are food and government–provided police and fire services, respectively. Assume the budget constraint

$$(4) \qquad y = x_T + px_N$$

where y is real income of the representative consumer-worker and p is the relative price of the nontraded service, both expressed in terms of the traded commodity (the numeraire).

This utility structure yields nonunitary income elasticities of demand for the two products. Maximizing (3) subject to (4) yields first-order conditions solvable for demand functions:

$$(5) \quad x_N = (1-\delta)p^{-1}(y - \bar{x}_T) + \delta\bar{x}_N$$

$$(6) \quad x_T = \delta y + (1-\delta)\bar{x}_T - \delta p\bar{x}_N.$$

The differing income elasticities of demand implied by this structure for the two products are made more transparent following some mathematical manipulation to yield

$$(7) \quad \hat{x}_N = -\left(1 - \frac{\delta\bar{x}_N}{x_N}\right)\hat{p} + \left(1 + \frac{(1-\delta)\bar{x}_T - \delta p\bar{x}_N}{px_N}\right)\hat{y}$$

$$(8) \quad \hat{x}_T = -\left(\frac{\delta p\bar{x}_N}{x_T}\right)\hat{p} + \left(1 - \frac{(1-\delta)\bar{x}_T - \delta p\bar{x}_N}{x_T}\right)\hat{y}$$

where $\hat{x}$ denotes $dx/x = d(\ln x)$. In the cross-country context of this paper, $\hat{x}$ is interpreted as a percentage difference between two countries. For example, a 1-percent-higher per capita income in country B relative to country A will cause B's per capita demand for the nontraded service to be $1 + [(1-\delta)\bar{x}_T - \delta p\bar{x}_N]/px_N$ percent higher than A's and will cause B's per capita demand for the traded commodity to be $1 - [(1-\delta)\bar{x}_T - \delta p\bar{x}_N]/x_T$ percent higher than A's. The nontraded service (traded commodity) will be the luxury (necessity) in consumption if the parameter-weighted minimum-consumption requirement for the traded commodity, $(1-\delta)\bar{x}_T$, exceeds that for the nontraded service (expressed in the numeraire), $\delta p\bar{x}_N$, and vice versa.

The demand for the nontraded service relative to the traded commodity (X) is

$$(9) \quad \hat{X} = \widehat{(X_N/X_T)} = \widehat{(x_N/x_T)} = \hat{x}_N - \hat{x}_T = -\sigma_D\hat{p} + \left(\frac{x_T + px_N}{x_T px_N}[(1-\delta)\bar{x}_T - \delta p\bar{x}_N]\right)\hat{y}$$

where X_N (X_T) denotes aggregate demand for the nontraded service (traded commodity) and σ_D is the elasticity of substitution in consumption; formally, $\sigma_D = 1 - (\delta\bar{x}_N/x_N) - (\delta p\bar{x}_N/x_T)$, which is likely to be positive and close to 1. Per capita GDP's coefficient may be positive or negative; a 1-percent-higher per capita income in country B will cause B's relative demand for the nontraded service to be higher (lower) than A's if the weighted minimum-consumption requirement for the traded commodity is greater (less) than that for the nontraded service.

Is there reason to believe a priori that the minimum-consumption requirement per capita for traded commodities exceeds that for nontraded services? The theoretical model reveals no such presumption. However, casual observation of per capita consumption patterns of the poorest countries in Kravis et al.'s (1982) data set (group I) suggests that the minimum-consumption requirement for commodities is likely to dwarf that for services. The only product group in Kravis et al. (1982) that included commodities (services) *exclusively* was food (government compensation for services provided). In terms of international prices, group I's per capita GDP in 1975 was only 9 percent of U.S. per capita GDP; yet 38 percent of this group's low per capita GDP was spent on food, while only 5 percent was spent on government compensation for services provided. Also, Linda C. Hunter and James R. Markusen (1988) used the same data set to estimate linear expenditure systems by Kravis et al.'s (1982) product groups; the results suggested that nontraded services (traded commodities) had income elasticities greater (less) than 1. Nevertheless, the empirical results in Section II will systematically reveal whether the coefficient on $\hat{y}$ is positive or negative.

Finally, for the special case in which $\bar{x}_N$ is zero, the coefficient on $\hat{y}$ is positive, and σ_D equals 1. This will be of interest for Section II.

B. *Supply*

The purpose of this section is to motivate a function for the supply of nontraded services relative to traded commodities in the representative country. I assume a standard simple-general-equilibrium framework similar to that in Ronald W. Jones (1965) for production of these two goods, using two factors: capital (K) and consumer-workers (L), the endowment of which is fixed at a point in time for each country. Perfectly competitive firms are assumed to minimize costs given the constant-returns-to-scale technology, yielding the optimum input requirements per unit of output:

$$\boldsymbol{\beta} = \begin{bmatrix} \beta_{LN} & \beta_{LT} \\ \beta_{KN} & \beta_{KT} \end{bmatrix}. \tag{10}$$

Each β_{ij} ($i = $ L,K; $j = $ N,T) is a function of the relative factor price (i.e., the wage rate [W] relative to the rental rate on capital [R]) and the state of productivity (τ_{ij}) in the country. An assumption of full employment of both factors requires

$$\beta_{LN} X_N + \beta_{LT} X_T = L \tag{11}$$

$$\beta_{KN} X_N + \beta_{KT} X_T = K \tag{12}$$

where L (K) is the overall endowment of labor (capital) and X_N (X_T) is aggregate production of the nontraded service (traded commodity). In a competitive equilibrium with both goods produced, unit costs must reflect market prices of the goods:

$$\beta_{LN} W + \beta_{KN} R = P_N \tag{13}$$

$$\beta_{LT} W + \beta_{KT} R = P_T \tag{14}$$

where all factor prices (W, R) and goods prices (P_N, P_T) are expressed in terms of a monetary unit, as in Jones (1965).

The production framework follows closely sections 2, 3, and 9 in Jones (1965). Hence, derivations for the solution need not be reproduced but are available from the author upon request. With some mathematical manipulation, the production framework can be solved for the supply of nontraded services relative to traded commodities (X) as a function of their relative price level (p), the capital:labor endowment ratio ($k = K/L$), and the level of productivity in traded commodities relative to nontraded services (Π):

$$\hat{X} = \sigma_S \hat{p} - (1/|\lambda|)\hat{k} - (1+\sigma_S)\hat{\Pi} \tag{15}$$

where the level of productivity in each industry is a weighted average of the level of productivity of each factor in that industry (τ_{ij}), $|\lambda| = \beta_{LN} X_N / L - \beta_{KN} X_N / K = \beta_{KT} X_T / K - \beta_{LT} X_T / L$, σ_S is the elasticity of substitution between goods in production (along the transformation schedule) as in Jones (1965), and $\sigma_S > 0$. In the cross-country context of this paper, a 1-percent-higher level of productivity in traded commodities relative to nontraded services in B compared with A will cause B's relative supply of nontraded services to traded commodities to be $1+\sigma_S$ percent lower than A's. The coefficient for the capital:labor ratio is ambiguously signed, depending upon relative factor intensities in production. If nontraded services are relatively labor-intensive in production (i.e., $|\lambda| > 0$), a 1-percent-higher capital:labor ratio in B relative to A will cause B's supply of nontraded services relative to traded commodities to be lower than A's.

C. *Equilibrium*

Demand function (9) and supply function (15) can be solved for the equilibrium relative price level (or real exchange rate), p, and the equilibrium relative output level, X, in the representative country:

$$(16)\quad \hat{p} = \frac{1+\sigma_S}{\sigma_D+\sigma_S}\hat{\Pi} + \frac{1}{(\sigma_D+\sigma_S)|\lambda|}\hat{k} + \frac{[(1-\delta)\bar{x}_T - \delta p\bar{x}_N](x_T+px_N)}{(\sigma_D+\sigma_S)(x_T p x_N)}\hat{y}$$

$$(17)\quad \hat{X} = -\frac{\sigma_D(1+\sigma_S)}{\sigma_D+\sigma_S}\hat{\Pi} - \frac{\sigma_D}{(\sigma_D+\sigma_S)|\lambda|}\hat{k} + \frac{\sigma_S[(1-\delta)\bar{x}_T - \delta p\bar{x}_N](x_T+px_N)}{(\sigma_D+\sigma_S)(x_T p x_N)}\hat{y}.$$

Equation (16) demonstrates how the productivity-differentials, relative-factor-endowments, and Linder hypotheses are all potentially relevant for explaining variation across countries in the equilibrium relative price of nontraded services to traded commodities (and the general price level). A 1-percent-higher productivity in traded commodities relative to that in nontraded services in country B compared with country A will cause B's relative price level to be $(1+\sigma_S)/(\sigma_D+\sigma_S)$ percent higher than A's, supporting the productivity-differentials model. A 1-percent-higher capital:labor ratio in B relative to A will cause B's relative price level to be $1/[(\sigma_D+\sigma_S)|\lambda|]$-percent higher than A's if nontraded services are relatively labor-intensive in production ($|\lambda| > 0$), supporting the relative-factor-endowments hypothesis. A 1-percent-higher per capita income in B relative to A will cause B's relative price level to be higher if the weighted minimum-consumption requirement for traded commodities exceeds that for nontraded services, implying an income elasticity of demand for nontradeables (tradeables) greater (less) than one.

Thus, all three hypotheses potentially can explain structural variation in the real exchange rate. Since per capita income is correlated positively with the capital:labor ratio and the level of productivity in commodities relative to services across countries, earlier studies have not tried to distinguish empirically among the relative importances of these three channels. However, if capital:labor ratios and relative-productivity measures are available, a ready method of distinguishing between the demand and supply roles of per capita income is to examine empirically the cross-country relationship between per capita income and the *output* of nontraded services relative to traded commodities, as demonstrated by equation (17). A 1-percent-higher productivity in traded commodities relative to nontraded services in B compared with A will cause B's output of nontraded services relative to traded commodities to be $\sigma_D(1+\sigma_S)/(\sigma_D+\sigma_S)$ percent *lower* than A's. A 1-percent-higher capital:labor ratio in B relative to A will cause B's output of nontraded services relative to traded commodities to be $\sigma_D/[(\sigma_D+\sigma_S)|\lambda|]$ percent *lower* than A's. However, a 1-percent-higher per capita income in B relative to A will cause B's relative output of nontraded services to traded commodities to be *higher* than A's if, to be consistent with equation (16), the income elasticity of demand for nontradeables (tradeables) is greater (less) than one.

The theoretical arguments are illustrated in Figure 1. Country B might have a higher relative price level than A because B has a higher productivity in traded commodities relative to nontraded services or a higher capital:labor ratio (assuming nontraded services are labor intensive) or both, causing a lower supply of nontraded services relative to traded commodities. However, if nontraded services (traded commodities) are luxuries (necessities) in consumption, higher-per-capita-income country B might have a higher relative price level than A

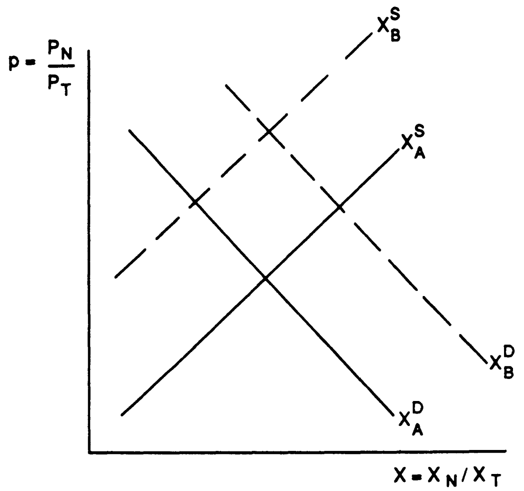

FIGURE 1. RELATIVE DEMAND AND RELATIVE SUPPLY CURVES FOR COUNTRIES A AND B

because of a higher *relative demand* for nontraded services. Only by examining empirically both reduced forms or their underlying structural equations could one hope to disentangle these three influences; these are examined next.

II. Empirical Results

Recent estimates of capital and labor endowments and of levels of productivity in commodities and in services across countries now make it possible to distinguish empirically among the three competing explanations for the robust positive correlation between countries' price levels and their per capita GDP's. Edward E. Leamer (1984) provides measures of capital and labor endowments for numerous countries circa 1975, of which 23 countries overlap with the 34 in Kravis et al. (1982) and Kravis and Lipsey (1983). The technique of Kravis et al. (1983) could be used to approximate the level of productivity in commodities relative to services for 21 of these countries.[4]

A. *Reduced-Form Estimates*

Given these 1975 estimates of capital: labor endowment ratios (k) and levels of productivity in commodities relative to services (Π), econometric analogues to reduced-form equations (16) and (17) could be estimated using ordinary least squares (OLS). Estimation of the log-linear version of (16) yields:[5]

$$\text{(18)}\quad \ln p = \underset{(12.68)}{-2.81} + \underset{(2.25)}{0.17\ln\Pi} + \underset{(2.84)}{0.23\ln k} + \underset{(1.67)}{0.18\ln y}$$

($\bar{R}^2 = 0.90$, RMSE $= 0.14$; t statistics in parentheses). Equation (18) suggests that each supply-oriented hypothesis for the relationship between the real exchange rate and per capita GDP has partial explanatory power. The level of productivity in commodities relative to services has the expected positive effect on the price of services relative to commodities, according to the productivity-differentials hypothesis; the coefficient estimate is statistically significant at the 2.5-percent level (one-tailed t test).[6]

[4]This explains the 21 countries for regressions (1) and (2). Capital and labor (LABOR1) for 1975 are from Leamer (1984 appendix table B.1). The level of productivity in (traded) commodities relative to (nontraded) services, $\Pi = \Pi_T/\Pi_N$, is approximated by the ratio of national output in commodities industries to the level of employment in commodities industries divided by the ratio of national output in services industries to the level of employment in services industries, that is, $(X_T/L_T)/(X_N/L_N)$, the inverse of the calculation in Kravis et al. (1983) for the level of productivity in services relative to commodities. Employment data are from the International Labour Organization's (1979) *Year Book of Labour Statistics*, as in Kravis et al. (1983). The output of commodities relative to services and all other data are from table 6-12 in Kravis et al. (1982).

[5]Treating the coefficients of $\hat{\Pi}$, $\hat{k}$, and $\hat{y}$ in (16) and (17) as constants, indefinite integration of those equations yields log-linear forms with constants appended.

[6]One referee noted that differences across countries in $(X_T/L_T)/(X_N/L_N)$, the proxy for Π_T/Π_N, could largely reflect differences across countries in their capital per unit of labor in (traded) commodities relative to (nontraded) services—the latter denoted k_T/k_N—rather than differences in Π_T/Π_N. As noted in Section I, each country's β_{LT} ($= L_T/X_T$) and β_{LN} ($= L_N/X_N$) are negative functions of the country's states of productivity (τ_{LT} and τ_{LN}, respectively) and of the country's relative factor price (W/R). Assuming

The capital:labor endowment ratio has a positive effect on the relative price level, suggesting that services are relatively labor-intensive in production, consistent with the relative-factor-endowments hypothesis; the coefficient estimate is significant at the 1-percent level. The presence of both k and Π has significantly eroded the explanatory power of per capita income.[7]

However, real per capita income is still positively related to the price of services relative to commodities, albeit only at the 10-percent significance level. In the context of the model, the remaining statistical significance of this coefficient suggests that per capita income may also be influencing the relative price level through demand. However, this positive estimate is also consistent with per capita GDP having some residual influence through supply on the real exchange rate unrelated to capital:labor ratios and relative productivity levels. A ready method of distinguishing empirically between a potential demand or supply role for per capita income is to examine the cross-country relationships between the *output* of services relative to commodities and Π, k, and y, as suggested by equation (17).

Ordinary-least-squares estimation of the log-linear version of (17) yields

$$(19)\quad \ln X = \underset{(1.42)}{0.45} - \underset{(0.89)}{0.10\ln\Pi} - \underset{(2.17)}{0.26\ln k} + \underset{(1.73)}{0.26\ln y}$$

($\bar{R}^2 = 0.13$, RMSE $= 0.20$; t statistics in parentheses). Consistent with the relative-factor-endowments and productivity-differentials models as well as equation (18), a higher level of productivity in commodities relative to services or a higher capital:labor ratio is associated with a lower output of services relative to commodities, although the coefficient estimate for Π is not statistically significant. Moreover, a higher per capita income is associated with a *higher* relative output of services to commodities. In the context of the model, this result suggests that a higher per capita income causes a higher relative price level because of a greater *demand* for nontraded services relative to traded commodities. The coefficient estimate for y is statistically significant at the 10-percent level (one-tailed t test).

B. *Simultaneous-Equations Estimates*

Although the results presented in reduced-form equations (18) and (19) are encouraging to the hypothesis that the positive relationship between per capita income and the relative price level is also attributable to a Linder-type demand channel, the statistical evidence is far from conclusive. Moreover, the coefficients from the reduced-form equations are nonlinear combinations of the structural parameters from the underlying

Hicks neutrality, $\hat{\tau}_{LN} - \hat{\tau}_{LT} = \hat{\Pi}_T - \hat{\Pi}_N = \hat{\Pi}$, implying that $\overline{(X_T/L_T)/(X_N/L_N)}$ is a positive function of $\hat{\Pi}$; yet $\overline{(X_T/L_T)/(X_N/L_N)}$ could also be reflecting $\overline{(k_T/k_N)}$ if countries are using different cost-minimizing relative factor intensities owing to differing wage:rental ratios [variation in which is not already explained by capital:labor endowment ratios, another right-hand-side variable in eq. (18)]. However, this latter possibility does not seem to be empirically confirmed. While calculations of k_T/k_N for all 21 countries was beyond the scope of this study, ready estimates of such intensities were available for six "country groups" (I–VI), reported in Kravis et al. (1983 table 12). Those authors found no systematic pattern for k_T/k_N across country groups. Moreover, I found no systematic correlations of k_T/k_N with respective observations on $(X_T/L_T)/(X_N/L_N)$, y, k, p, or X for these groups.

[7]Note that this specification differs from that in Clague (1986), which retained per capita GDP as a proxy for (non-natural-resource) relative factor abundances and relative productivity levels. Clague notes, "Ideally, we would like to treat real [per capita] income as an endogenous variable, but since we cannot measure resource endowments per capita, efficiency levels, and other determinants of real income, we are forced to use [per capita income] as an exogenous variable" (p. 320). Not surprisingly, a regression of per capita GDP on k and Π reveals strong evidence for interpreting per capita GDP as a proxy for capital:labor ratios and for levels of productivity in commodities relative to services, respectively. The estimated regression for the same 21 countries is

$$\ln y = \underset{(0.63)}{-0.31} + \underset{(7.88)}{0.68\ln k} + \underset{(2.05)}{0.31\ln\Pi}$$

($\bar{R}^2 = 0.85$, RMSE $= 0.31$; t statistics in parentheses).

structural equations. Since this particular model is overidentified, the underlying structural parameter estimates for the relative demand and supply variables cannot be determined immediately from reduced-form equations (18) and (19).[8]

However, two-stage least squares (2SLS) conveniently enables determination of the structural parameter estimates of theoretical equations (9) and (15).[9] Two-stage least-squares estimation of log-linear versions of (9) and (15) yields the following demand (D) and supply (S) equations for the relative output of services to commodities:

$$(20)\quad \ln X^{D} = \underset{(1.87)}{-1.96} - \underset{(2.10)}{0.90\ln p} + \underset{(1.79)}{0.40\ln y}$$

$$(21)\quad \ln X^{S} = \underset{(1.15)}{4.61} + \underset{(1.07)}{1.48\ln p} - \underset{(1.00)}{0.35\ln \Pi} - \underset{(1.20)}{0.60\ln k}$$

(RMSE = 0.11 and 0.33, respectively; t statistics in parentheses).

Several points are worth noting. First, empirical implementation of theoretical structural equations (9) and (15) yields results consistent with the Linder-type demand hypothesis. The demand for services relative to commodities is significantly (at the 5-percent level, one-tailed t test) related to per capita income, holding constant the influences of relative factor endowments and productivity differentials on relative supply. In the context of the model, this suggests that the income elasticity of demand for nontraded services (traded commodities) is greater (less) than one.

Second, the estimate of the elasticity of substitution in demand (σ_D), 0.9, is statistically significant and has a plausible magnitude. As noted in Section I, for the special case in which the minimum consumption requirement for nontraded services ($\bar{x}_N$) is zero, σ_D should equal 1 or $-\sigma_D = -1$. In fact, the linear restriction that the coefficient estimate equals -1 could not be rejected even at the 10-percent significance level ($F_{[1, 18]} = 0.056$). This suggests that $\bar{x}_N$ is not significantly different from zero, consistent with earlier observations noted in Section I.

Third, the relative price level, the level of productivity in services relative to commodities, and the capital:labor endowment ratio all have the expected relationships with the supply of services relative to commodities, although their coefficient estimates are not significant. The linear restriction on this supply equation's coefficient estimates implied by theoretical supply function (15)—that the coefficients of the price and Π variables should sum to -1—was tested also. This linear restriction was rejected at the 10-percent significance level, but could not be rejected at the 5-percent level $F_{[1, 17]} = 3.838$).

Fourth, as noted in footnote 2, the empirical distinction between services and nontradeables and between commodities and tradeables is a fairly minor one, resting on the treatment of construction activity. Equations (18)–(21) were also estimated using nontradeables/tradeables data instead of services/commodities data. The results are similar but are omitted here for brevity; these are available from the author upon request.

In concluding this section, I emphasize a key empirical result that has been omitted in this literature: the null hypothesis that per capita income has no effect on real exchange rates and national price levels *via demand* is rejected.

III. Conclusions and Policy Implications

This study has provided empirical evidence that the systematic cross-country relationship between real per capita incomes

[8]This system would be just identified if one of the supply variables were deleted.

[9]The t statistics reported are asymptotically valid. Given that there are only three exogenous variables, 2SLS estimation can only be used appropriately here to determine *relative* outputs and prices.

and national price levels (or real exchange rates), commonly attributed to the supply-oriented productivity-differentials and relative-factor-endowments hypotheses, can also be attributed partly to a demand-oriented "Linder-type" hypothesis. Assuming nonhomothetic tastes, countries with higher real per capita income will exhibit, in equilibrium, stronger demand for nontraded services relative to traded commodities, raising their relative price. Empirical evidence showed that, even when differences across countries in capital:labor endowment ratios and levels of productivity in commodities relative to services are accounted for, real per capita income still has a significant positive correlation with relative price levels and outputs. The results are consistent with recent studies emphasizing the importance of nonhomotheticity of tastes for explaining consumption and trade patterns across countries (cf. Jerry G. Thursby and Marie C. Thursby, 1987; Hunter and Markusen, 1988). Yet with only 21 usable observations from the Kravis et al. (1982) data set, the results are only encouraging, not conclusive, and more empirical research along these lines seems warranted.

Finally, two policy implications are raised by the issues addressed in this study. First, some of the U.S. dollar's dramatic real appreciation vis-à-vis foreign currencies between 1980 and 1985 and the subsequent large real depreciation from 1985 to 1988 should not be attributed to "disequilibrium," or exchange-rate misalignment. Per capita GDP of most other major industrialized countries fell relative to that of the United States in the first half of the 1980's and rose subsequently, although not nearly by the magnitude of actual real exchange-rate changes. Second, the Plaza Accord of September 1985, which indicated that the major industrialized countries' governments coordinated an effort to facilitate the U.S. dollar's real depreciation toward some "zone," and massive 1988 coordinated central bank interventions, which revealed that the same countries coordinated an effort to prevent the dollar's depreciation below this zone, both suggest that the governments have some notion of the "equilibrium" real exchange rate. The results here suggest that relative productivity levels, capital:labor ratios and tastes can explain as much as 90 percent of the variation across countries in real exchange rates. Consequently, the variation in such diverse real economic variables over time will tend to obscure the policy identification of the equilibrium real exchange rate.

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