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ABSTRACT

Economists have long investigated theoretically and empirically the relationship between government spending and equilibrium real exchange rates. As Frenkel and Razin (1996) summarize for a small open economy, government expenditures (financed by lump-sum taxes) influence real exchange rates via a *resource-withdrawal* channel and a *consumption-tilting* channel. Recent theoretical and empirical studies, such as Froot and Rogoff (1991), Rogoff (1992), De Gregorio, Giovannini, and Krueger (1994), De Gregorio, Giovannini, and Wolf (1994), De Gregorio and Wolf (1994), and Chinn and Johnston (1996), have focused only upon the effects of government spending through the resource-withdrawal channel. Extending Frenkel and Razin (1996), this paper generates closed-form theoretical solutions for the relationships among the real exchange rate, relative per capita private consumption, relative per capita government consumption, and relative per capita tradables and nontradables production in a two- country general equilibrium model. Using relative price level, private and government per capita consumption, and relative productivity data from the Summers and Heston (1991) Penn World Tables and OECD (1996) data for a sample of OECD countries relative to the United States, we estimate the model's structural equations. The results suggest that government expenditures influence equilibrium real exchange rates *approximately equally* via the resource-withdrawal and consumption-tilting channels. Moreover, the results imply that government spending and private consumption are *complements* in utility.

RESUMEN

Desde hace tiempo los economistas han estado investigando teórica y empíricamente la relación entre el gasto público y el tipo de cambio real de equilibrio. Como lo resumen Frenkel y Razin (1996), para una economía abierta pequeña el gasto público (financiado por impuestos de suma fija) influye sobre el tipo de cambio real a través de un canal de *retiro de recursos* y de un canal de *inclinación del consumo*. Estudios teóricos y empíricos recientes, tales como los de Froot y Rogoff (1991); Rogoff (1992); De Gregorio, Giovannini y Krueger (1994); De Gregorio, Giovannini y Wolf (1994); De Gregorio y Wolf (1994) y Chinn y Johnston (1996), se han concentrado solamente sobre el canal de retiro de recursos. Extendiendo el argumento de Frenkel y Razin (1996) este trabajo genera soluciones teóricas de forma cerrada acerca de la relación entre el tipo de cambio real, el consumo privado per cápita relativo, el consumo público per cápita relativo y la producción per cápita relativa de bienes transables y no transables en un modelo de equilibrio general de dos países. Estimamos las ecuaciones estructurales del modelo usando datos sobre el nivel de precios relativos, los consumos per cápita privado y público, y la productividad relativa provistos por Summers y Heston (1991), las Penn World Tables y datos de la OCDE (1996) para una muestra de países integrantes de esa organización medidos en relación con los Estados Unidos. Los resultados sugieren que el gasto público influye sobre el tipo de cambio real de equilibrio *de modo aproximadamente igual* tanto a través del canal de retiro de recursos como a través del canal de inclinación del consumo. Más aún, los resultados implican que el gasto público y el consumo privado son *complementos* en términos de utilidad.

Economists have long investigated theoretically and empirically the relationship between government spending and real exchange rates, as recently highlighted in sections of Froot and Rogoff (1995), Obstfeld and Rogoff (1996), and Rogoff (1996). Frenkel and Razin (1996) summarize nicely the relationship between government spending and real exchange rates in an intertemporal, neoclassical framework.[1] In the context of a two-period, small open economy model, Frenkel and Razin note that government spending influences the private sector and the real exchange rate essentially through two channels: the *resource-withdrawal* and *consumption-tilting* channels. Regarding the first channel, the influence of government expenditure is similar to that of a negative supply shock; the effect on private consumption and real exchange rates will depend upon the proportion of government consumption spending falling on nontradables versus that falling on tradables. Regarding the second channel, Frenkel and Razin point out that the effect of government expenditure on private consumption levels and the real exchange rate will depend upon the "characteristics of the utility function" (p. 165). They note the potential importance of complementarity versus substitutability between private consumption and government consumption in utility, which dictates how the marginal rate of intertemporal substitution in utility is influenced by government expenditure levels.

Several recent studies of the determinants of equilibrium real exchange rates have provided neoclassical models amenable to econometric implementation—notably Froot and Rogoff (1991), Rogoff (1992), De Gregorio, Giovannini, and Krueger (1994), De Gregorio, Giovannini, and Wolf (1994), De Gregorio and Wolf (1994), and Chinn and Johnston (1996). Although each of these empirical studies incorporates government spending, all have focused upon the *resource-withdrawal* channel for government spending, ignoring the potential relevance theoretically and empirically of complementarity versus substitutability in utility of private and government consumption, as raised by Frenkel and Razin. De Gregorio, Giovannini, and Krueger (1994), De Gregorio, Giovannini, and Wolf (1994), and De Gregorio and Wolf (1994) present static models where government expenditure (financed by lump-sum taxes) falls exclusively on nontradables and the effect on the real exchange rate is entirely through the resource-withdrawal channel. They find a significant short-run (but not long-run) effect of government spending on the real exchange rate. In intertemporal neoclassical contexts, Rogoff (1992) and Chinn and Johnston (1996) find significant empirical effects of the share of government expenditures on real exchange rates. However, as in the static models above, government spending only works through resource withdrawal, though these models allow government spending on both tradables and nontradables.[2]

This paper introduces government expenditure into a model of two countries' representative consumers' behavior to investigate how differences in government expenditures between countries (alongside productivity differences) potentially can explain structural departures from purchasing power parity (PPP) and movements in equilibrium real exchange rates. Extending Frenkel and Razin (1996), this paper generates closed-form theoretical solutions for the relationships among the real exchange rate, relative per capita private consumption, relative per capita government consumption, and relative per capita tradables and nontradables production in a general equilibrium model of two countries' representative consumers. In contrast to the intertemporal neoclassical models of Penati (1987), Rogoff (1992) and Chinn and Johnston (1996), government expenditure influences consumers' utility explicitly here, either as a potential substitute for or complement to private consumption. In further contrast to De Gregorio, Giovannini and Krueger (1994), De Gregorio, Giovannini and Wolf (1994), and De Gregorio and Wolf (1994), government expenditure is allowed to fall on tradables as well as nontradables. Application to the model's structural equations of relative price level, relative per capita nontradables production, and relative per capita private and government consumption data from the Summers and Heston (1991) Penn World Tables and OECD (1996) data for a sample of OECD countries relative to the United States suggests three interesting results. First, government expenditures influence equilibrium real exchange rates in the medium-run via both the resource-withdrawal and consumption-tilting channels. Second, we find empirically that the consumption-tilting effect of government expenditure on real exchange rates is *approximately equal* to the resource-withdrawal effect. Third, government consumption and private consumption are *complements* in utility.

While broadly aimed at better understanding the potential role for government spending in affecting structural PPP departures in the context of an intertemporal neoclassical model, this study additionally sheds light upon two secondary, but related, issues. First, as is widely known, aggregate consumption fluctuations are not highly correlated across countries. Recent work in open-economy macroeconomics has investigated whether the distinction between nontradable versus tradable goods can explain the large and persistent movements in relative national price levels and relative consumptions among industrialized economies. Backus and Smith (1993) highlight the importance of this issue, but find weak empirical support for a monotonic relationship between the real exchange rate and relative consumption. Because changes in relative prices and relative consumptions are driven in their model by endowment shocks to tradables and nontradables, the authors qualify their weak empirical results by noting prominently that a "more general model"—that is, one admitting "demand-side shocks"—might help sort out the issues. The present model employs changes in relative government expenditures to consider such demand-side shocks' effects on the real exchange rate.

Second, few studies have attempted to evaluate testable implications of dynamic stochastic general equilibrium models of real exchange rates, as noted by Taylor (1995). The closed-form theoretical solutions in our study for the relationships among relative (per capita) consumptions, relative nontradables production, relative government expenditures, and the real exchange rate lend themselves to empirical evaluation. The results offer insight into the relationship between government spending and real exchange rates in an intertemporal setting and the weak empirical correlations between relative per capita consumption and real exchange rates documented earlier.

The remainder of this paper is as follows. The model in section I suggests multiple roles for government spending (financed by lump-sum taxes) in explaining the movements of relative consumption and relative prices in a dynamic setting. In section II, we describe econometric analogues to the intertemporal and intratemporal equilibrium conditions derived in section I. Section III presents empirical results from estimating these equilibrium conditions and finds plausible parameter estimates of the elasticity of intertemporal substitution, the relative share of nontradable goods in utility, and the role of government expenditures in explaining relative consumption and real exchange rate movements, using data from the UN's International Comparisons Program and OECD's *Annual National Accounts* (1996). Section IV concludes that government spending can influence equilibrium real exchange rates via *both* the resource-withdrawal and consumption-tilting channels, with the consumption-tilting channel having approximately equal impact on the real exchange rate as the resource-withdrawal channel.

I. A Two-Country Equilibrium Model with Government Expenditures

Frenkel and Razin (1996, sections 8.2–8.4) describe theoretically the relationship between government expenditures and the real exchange rate using an intertemporal neoclassical model. In the context of a small open economy, they outline the potential complementary roles for government spending influencing private consumption behavior via the resource-withdrawal and consumption-tilting channels. However, in their two-country extension (when either country can influence the world interest rate), they introduce government spending into the utility function in a "separable way," implying that the marginal rate of intertemporal substitution in private consumption "does not depend on the level of government spending" (p. 262).

In the following, we outline a two-country model where both the consumption-tilting and resource-withdrawal channels of government expenditure are introduced explicitly. The model is a direct extension of Balvers and Bergstrand (1997), amended to include a government sector. We first describe the model and then derive intertemporal and intratemporal equilibria for specific preferences. Estimable closed-form solutions are obtained for a nested utility function with constant relative risk aversion in consumption and with some symmetry conditions imposed on the preferences of the two representative consumers.

A. Description of the Model

Following Lucas (1978), we abstract from investment decisions by assuming endowment economies. Stochastic production processes for all goods are owned by the consumers and yield perishable outputs. Each country (foreign variables denoted by *) consists of a tradables production process, a nontradables production process, and one infinitely-lived representative consumer with a time- additive utility function. The tradables produced in both countries are perfect substitutes.[3]

In the home country and analogously abroad, the representative consumer maximizes the expected present discounted value of the stream of future utilities from private consumption and the consumption of publicly provided goods:

$$Max\, E_0 \sum_{t=0} \beta^t u(c_t, g_t), \tag{1}$$

$$c_t = v\left(c_t^T,\ c_t^N\right), \tag{2}$$

$$g_t = \mathrm{w}\left(g_t^T,\ g_t^N\right), \tag{3}$$

where E_0 represents the expectation conditional on information at time 0, β is the standard discount factor, and u(•) is a current-period utility function strictly concave in the consumption index c_t and dependent on g_t (per capita government expenditure). The consumption index at time t, c_t in equation (2), represents an optimally chosen basket of the tradable good, c_t^T, and the nontradable good, c_t^N. Preferences over both goods embodied in the consumption index are assumed to be homothetic in order that an exact price index may be defined. Without loss of generality, we then may apply a monotonic transformation such that v(•) in equation (2) is homogeneous of degree one and concave in the decision variables. In equation (3), g_t represents government consumption, which is produced from government purchases of tradables, g_t^T, and nontradables, g_t^N, via function w(•). Government consumption is exogenous to the individual consumer and is financed by lump-sum taxes.

To obtain closed-form solutions for the real exchange rate and relative consumption (which also make the model amenable to empirical research), we assume a constant relative risk aversion (CRRA) current-period utility function for consumption but with generally specified preferences for the government expenditures (equation (4)), and a Cobb-Douglas subutility function (equation (5)):

$$u\left(c_t, g_t\right) = z\left(g_t\right) + h\left(g_t\right)\left(c_t\right)^{1\square\square} / (1 - \square), \quad \square > 0 \qquad (4)$$

$$c_t = \left(c_t^T\right)^{1/(1+\square)}\left(c_t^N\right)^{\square/(1+\square)}, \qquad \square > 0 \qquad (5)$$

Letting subscripted variables denote first derivatives, assume $z_g(g) > 0$. Then government consumption (g) and private consumption (c) are complements whenever $h_g(g) > 0$ and substitutes whenever $h_g(g) < 0$. In the case of substitutes, it can be assured that $u_g(c,g) > 0$ only if $z_g(g) > 0$. The preferences of the two countries' representative consumers may differ intertemporally in discount factors $\square$ and $\square^*$ *and* in functions $h(g)$ and $z(g)$ versus $h^*(g)$ and $z^*(g)$, respectively, but parameters $\square$ and $\square$ are assumed identical across countries.

The nested structure of the utility function enables us to separate the representative consumer's decisions into an intratemporal decision concerning the distribution of overall consumption expenditure between the tradable and nontradable goods and an intertemporal decision concerning the demand for assets and the overall expenditure on current consumption. Thus, the two equilibrium conditions can be discussed separately.

Assume complete markets so that productivity shocks are insurable.[4] The Second Welfare Theorem now implies that the competitive equilibrium outcome will be equivalent to the Pareto optimal allocation as chosen by a social planner. This social planner maximizes the weighted average of the lifetime utilities of the two countries' representative consumers by choosing the distribution of the tradable good subject to the available quantity. Due to the time separability of the lifetime utility functions, the social planner solves the following decision problem for each period:

$$\max_{c_t^T,\, c_t^{T*}} \{\beta^t [z(g_t) + h(g_t)(c_t)^{1-\gamma}/(1-\gamma)] + \lambda\beta^{*t}[z^*(g_t^*) + h^*(g_t^*)(c_t^*)^{1-\gamma}/(1-\gamma)]\} \quad (6)$$

subject to:

$$c_t = (c_t^T)^{1/(1+\theta)}(c_t^N)^{\theta/(1+\theta)},\ c_t^* = (c_t^{T*})^{1/(1+\theta)}(c_t^{N*})^{\theta/(1+\theta)}, \quad (7)$$

The λ denotes the constant weight that the social planner places on the utility of the foreign consumer.[5] Equation (8) represents the period market-clearing conditions for nontradable goods in both countries.

$$c_t^N + g_t^N = y_t^N,\ c_t^{N*} + g_t^{N*} = y_t^{N*} \quad (8)$$

$$c_t^T + g_t^T + c_t^{T*} + g_t^{T*} = y_t^T + y_t^{T*}. \quad (9)$$

Equation (9) represents the period market-clearing condition for tradables goods, reflecting that the countries' tradable goods are perfect substitutes. As stated earlier, closed-form solutions are obtained by constraining some parameters of the utility functions to be equal, but the representative consumers can still differ with respect to rates of time preference, initial endowments, benefits derived from government expenditure, and consumption opportunities related to the nontradable good.

Finally, we define the real exchange rate, x_t, conventionally as:

$$x_t \;=\; e_t\, p_t^{*} / p_t \qquad (10)$$

where e_t is the nominal exchange rate (expressed in units of domestic currency per unit of foreign currency) and p_t (p_t^{*}) is the domestic (foreign) consumption-based price level.[6]

B. Intratemporal Equilibrium

The separability of the lifetime utility function implies a budgeting process where the consumer in each period maximizes the (intratemporal) value of the consumption index, c_t, in equation (5), subject to an after-tax budget constraint, B_t, given by:

$$B_t \;=\; p_t^T\, c_t^T \;+\; p_t^N\, c_t^N \qquad (11)$$

where p_t^T (p_t^N) is the domestic consumer price for the tradable (nontradable), and similarly for the foreign consumer. Choosing consumption of the tradable good to maximize equation (5) subject to equation (11) yields:

$$\square_t \;=\; (1+\square)^{\square 1}\left(c_t^T\right)^{\square\square/(1+\square)}\left(c_t^N\right)^{\square/(1+\square)} / p_t^T \qquad (12)$$

and similarly for the foreign country, where $\square_t$ is the Lagrange multiplier.

Given homotheticity of the subutility function (c_t), one can rewrite equation (11) as:

$$B_t \;=\; p_t\, c_t . \qquad (13)$$

Since the Lagrange multiplier equals the marginal benefit of a unit increase in the budget on the maximum subutility, we also have:

$$\square_t \;=\; \partial c_t \,/\partial B_t \;=\; 1/p_t \;. \tag{14}$$

Combining equations (12) and (14), and similarly for the foreign country, using the market- clearing conditions for the nontradable goods, the law of one price for tradable goods ($p_t^T = e_t\, p_t^{T*}$), and the definition of the real exchange rate, yields the intratemporal equilibrium condition:

$$x_t \;=\; (c_t^* / c_t)^{\square}[(y_t^{N*} \;\square\; g_t^{N*}) / (y_t^N \;\square\, g_t^N)]^{\square\square}. \tag{15}$$

Equation (15) illustrates the expected *resource-withdrawal* effect of government spending discussed earlier. A rise in per capita foreign government purchases of nontradables causes a rise in the real exchange rate, that is, a real appreciation of the foreign currency.

C. Intertemporal Equilibrium

In the intertemporal stage of the budgeting process, the social planner maximizes in each period equation (6), the weighted average of the two consumers' utilities, subject to the constraints in equations (7), (8) and (9). This yields a set of first-order conditions that, by eliminating the Lagrange multiplier, results in:

$$\frac{\left(c_t^T\right)^{\square\square/(1+\square)}\left(c_t^N\right)^{\square\square/(1+\square)}}{\left(c_t^{T*}\right)^{\square\square/(1+\square)}\left(c_t^{N*}\right)^{\square\square/(1+\square)}} \;=\; \square\,\frac{\square^{*t}h^*\!\left(g_t^*\right)\left(c_t^*\right)^{\square\square}}{\square^t h\left(g_t\right)\left(c_t\right)^{\square\square}}.$$

From the intratemporal equilibrium, the left hand side of equation (16) equals x_t so that the intertemporal equilibrium condition is:

$$x_t \;=\; \square(\square^*/\square)^t[h^*(g_t^*)/h(g_t)](c_t^*/c_t)^{\square\square}. \tag{17}$$

where □ and $(□^*/□)^t$ can be interpreted in the model's context as initial relative wealth and accumulated relative wealth, respectively.[7] Equation (17) illustrates the *consumption-tilting* effect of government spending discussed earlier and the dependence of the marginal rate of intertemporal substitution on relative government spending, omitted in recent studies of government spending and equilibrium real exchange rates. Higher per capita foreign government consumption may increase or decrease the real exchange rate, depending upon the complementarity or substitutability between government consumption and private consumption.

D. Interpretation

Figure 1 demonstrates the intratemporal equilibrium locus, $INTRA_t$, in logarithmic form with slope □. It has a positive slope since a higher desired foreign consumption level implies more demand so that the foreign price level and, accordingly, the real exchange rate needed for intratemporal equilibrium are higher. An increase in foreign government purchases of nontradables $({g^N_t}^*)$ withdraws resources from foreign nontradables production. The resulting excess demand drives up the relative price of nontradables abroad and the real exchange rate, lowering relative foreign private nontradables consumption expenditure (point A to point B in Figure 1).

Figure 1 also displays in logarithmic terms the negative relationship at time t between relative consumption and the real exchange rate along the intertemporal equilibrium locus, $INTER_t$, with slope -□. A higher relative foreign price level (i.e., real exchange rate) currently provides relatively more incentive for the foreign consumer to defer consumption to the future so that equilibrium current consumption abroad declines relative to the home country. An increase in foreign government consumption (g) can shift the $INTER_t$ curve up or down depending upon whether government consumption complements or substitutes for private consumption. If government consumption complements private consumption (i.e., $h_g(g)>0$), $INTER_t$ shifts up, raising the real exchange rate and relative consumption (point A to point C in Figure 1). If government consumption substitutes for private consumption (i.e., $h_g(g)<0$), the reverse happens with a rise in foreign government expenditures (point A to point D in Figure 1). In Figure 1, note the four possible quadrants for the equilibrium. Initial equilibrium point A assumes the foreign country has higher per capita consumption and price level than the home country.

The model can now be solved explicitly for the real exchange rate and relative consumption expenditure, as suggested by Figure 1. For empirical purposes, assume $h(g) = g^{\square}$ where $\square > 0$ ($\square < 0$) indicates government consumption complements (substitutes for) private consumption; analogously, let $h^*(g^*) = g^{*\square}$. Combining equations (15) and (17) then yields reduced forms:

$$x_t = \square^{\square/(\square+\square)} (\square^*/\square)^{[\square/(\square+\square)]t} [(y_t^{N*} - g_t^{N*})/(y_t^N - g_t^N)]^{-\square\square/(\square+\square)} (g_t^*/g_t)^{\square\square/(\square+\square)} \tag{18}$$

$$c_t^*/c_t = \square^{1/(\square+\square)} (\square^*/\square)^{[1/(\square+\square)]t} [(y_t^{N*} - g_t^{N*})/(y_t^N - g_t^N)]^{\square/(\square+\square)} (g_t^*/g_t)^{\square/(\square+\square)} \tag{19}$$

Initial wealth, rates of time preference, nontradables productivity *and* government expenditures all affect relative consumption and the real exchange rate.[8] Equation (19), moreover, implies that consumption levels in the two countries need not be highly correlated, as long as relative nontradables productivity or relative government expenditure varies substantially.

II. Econometric Issues

The reduction of the general equilibrium model to closed-form equilibrium conditions (15) and (17) and to reduced-form real exchange rate and relative consumption equations (18) and (19), respectively, allows estimation. In this section, we discuss the choice of data and relevant econometric issues.

Given the model describes medium-run behavior, a data set consistent with such behavior is optimal. Annual data may be most appropriate to evaluate a medium-run theoretical model. Higher frequency data, such as monthly or quarterly time series, would be more appropriate for explaining short- run real exchange rate behavior. Lower-frequency data, such as that averaged over five-year to fifteen- year intervals, is typically used for explaining long-run economic behavior. For a similar categorization, see De Gregorio, Giovannini, and Wolf (1994).

Since our model has implications for both the time-series and cross-sectional behavior of real exchange rates, a panel data set is potentially useful. Summers and Heston (1991) provide annual time series from 1950 to 1988 on relative per capita private consumption expenditures, relative per capita government consumption, and relative consumption price levels (or consumption-based real exchange rates) for 138 countries with the United States as the numeraire (US=100), designed for pooled cross- section time-series analysis. The only shortcoming is the absence of a decomposition of expenditures between tradables and nontradables. Fortunately, the *OECD Annual National Accounts, Volume II* (1996) enables construction of relative shares of consumption expenditures into nontradables (services) and tradables (commodities) using the same categorization as Kravis, Heston and Summers (1982) for the United States and ten other OECD countries over the years 1970 through 1988.[9]

The log-linear versions of reduced-form equations (18) and (19) potentially estimable by ordinary least squares (OLS) are:

$$\ln x_{it} = \sum_{j=1}^{10} \square_j^1 + \sum_{j=1}^{10} \{[\square/(\square+\square)][\ln(\square_j/\square)]\}\, trend_{jt} - \square[\square/(\square+\square)] \ln[(y_{it}^N \square g_{it}^N)/(y_t^N \square g_t^N)]$$

$$+[\square\square/(\square+\square)] \ln(g_{it}/g_t) + \square_{it}^1$$

$$\ln\left(c_{it}/c_t\right) = \sum_{j=1}^{10} \square_j^2 + \sum_{j=1}^{10} \{[1/(\square+\square)][\ln(\square_j/\square)]\}\,\mathrm{trend}_{jt} + [\square/(\square+\square)] \ln[(y_{it}^N \square g_{it}^N)/(y_t^N \square g_t^N)]$$

$$+ [\square/(\square+\square)] \ln(g_{it}/g_t) + \square_{it}^2$$

where x_{it} is the real exchange rate of country i relative to the United States in year t, c_{it} (c_t) is per capita consumption in country i (US), y_{it}^N-g_{it}^N $(y_t^N$-$g_t^N)$ represents per capita nontradables production net of government absorption in country i (US), and g_{it} (g_t) is per capita government consumption in country i (US).[10] Variable $trend_{jt}$ is a time trend when

$j=i$ and is 0 for $j \neq i$. $\square_j/\square$ is the discount rate in country j relative to the US discount rate when $j=i$. The $\square$'s are i.i.d. error terms and $\square_j^1$ and $\square_j^2$ are dummy variables assuming the value 1 when $j=i$ and 0 when $j \neq i$, to reflect exogenous differences in initial wealth.[11]

Since the data set includes time series as well as cross section observations, one needs to address the issue of data stationarity over time. If the individual time series are stationary in log-levels, coefficient estimates in these regressions are consistent and the student t-distribution can be used to evaluate their statistical significance. However, if the individual time series are stationary in first-differences of their log-levels but the series are cointegrated, OLS coefficient estimates are consistent but standard t-statistics would have to be adjusted to evaluate the coefficients' statistical significance.

Although the time-series dimension of our data (T=36) is fairly small by most time-series analyses standards, Levin and Lin (1992) show theoretically the increased power of testing for unit roots in short time series by pooling data cross-sectionally. In particular, they demonstrate that when the time dimension is of "moderate length (i.e., 25-100 periods)," pooling data cross-sectionally with only a small number of individuals can dramatically increase the power of the unit root test. They note that with only 25 time-series periods but a panel of 10 units (similar to this study), the power of the test exceeds 90 percent. Three studies (Frankel and Rose, 1996; Oh, 1996; and Wu, 1996) found evidence that real exchange rates are stationary in log-levels by pooling time-series data across country pairs.

Using the techniques in Levin and Lin (1992), we conducted similar tests of stationarity for our relative price level, relative (per capita) consumption level, and relative (per capita) government consumption level variables for the period 1953 to 1988 for all ten countries (relative to the United States).[12] The results of the tests for nonstationarity are presented in Tables 1–3. The tests indicated that the null hypothesis of nonstationarity could be rejected in favor of the alternative hypothesis of stationarity for all three variables at the 5 percent significance level, with or without intercepts, time trends, and/or fixed-year effects, consistent with the three studies for real exchange rates reported earlier.[13] Consequently, we are able to estimate specifications (20) and (21) in level form.

An econometric issue not yet addressed is the identification of the parameters. Equations (20) and (21) are reduced forms from a system of equations that are *overidentified*.[14] Consequently, indirect least squares cannot be used efficiently to identify the parameter estimates, but two-stage least squares (2SLS) can be used. Two-stage least squares estimation of:

$$ln\ x_{it} = \sum_{j=1}^{10} \square_j^3 + \square ln(c_{it}/c_t)\ -\ \square ln[(y_{it}^N \square g_{it}^N)/(y_t^N \square g_t^N)] + \square_{it}^3$$

$$ln\ x_{it} = \sum_{j=1}^{10} \square_j^4 + \sum_{j=1}^{10} [\ln(\square_j/\square)]\ \mathrm{trend}_{jt} \square \square \ln(c_{it}/c_t + \square \ln(g_{it}/g_t) + \square_{it}^4$$

can yield unique parameter estimates of the relative share of tradables in utility *(1/[1+□])*, the relative discount rates *(□$_j$/□)*, the elasticity of intertemporal substitution *(1/□)*, and degree of complementarity or substitutability of government consumption for private consumption *(□)*. Conventional 2SLS is applied. In the first stage, we estimate the reduced-form equation (21) to obtain the predicted values of ln(c_{it}/c_t). In the second stage, the predicted values of $ln(c_{it}/c_t)$, denoted $pvln(c_{it}/c_t)$, are used as an "instrument" for $ln(c_{it}/c_t)$. Hence, regressions (22) and (23) will use the predicted values of $\ln(c_{it}/c_t)$ from the first stage.

Finally, OLS estimation of these equations (reduced-forms or second-stage of 2SLS) will lead to consistent estimates. However, in the presence of potential autocorrelation and/or heteroskedasticity of the error terms, the standard errors of the coefficient estimates may be inefficient. To account for this, we employ the heteroskedasticity- and autocorrelation-consistent covariance estimator of Newey and West (1987).

III. Empirical Results

In this section, we present first the results of estimating reduced-form equations (20) and (21). The estimate of reduced-form equation (21) generates the instrument for estimating structural equations (22) and (23).

A. Reduced-Form Equations

OLS estimation of equations (20) and (21) yields:

$$\begin{aligned}
\ln x_{it} &= \underset{(18.65)}{4.3753} - \underset{(2.17)}{0.8429} \ln[(y_{it}^N - g_{it}^N)/(y_t^N - g_t^N)] + \underset{(2.18)}{0.3578} \ln(g_{it}/g_t) \\
&+ \underset{(0.98)}{0.0088}\, TrendAus_{it} - \underset{(2.08)}{0.0103}\, TrendCan_{it} - \underset{(0.56)}{0.0065}\, TrendDen_{it} \\
&+ \underset{(0.42)}{0.0046}\, TrendFin_{it} + \underset{(0.37)}{0.0032}\, TrendFra_{it} - \underset{(2.47)}{0.0212}\, TrendGre_{it} \\
&+ \underset{(0.45)}{0.0041}\, TrendIta_{it} + \underset{(3.34)}{0.0325}\, TrendJpn_{it} + \underset{(0.22)}{0.0022}\, TrendNor_{it} \qquad (24) \\
&+ \underset{(0.66)}{0.0042}\, TrendUK_{it} + \underset{(1.18)}{0.1479}\, DVCan_{it} - \underset{(1.36)}{0.4925}\, DVDen_{it} \\
&- \underset{(0.79)}{0.1530}\, DVFin_{it} - \underset{(1.68)}{0.5780}\, DVFra_{it} - \underset{(1.94)}{3.0579}\, DVGre_{it} \\
&- \underset{(2.04)}{0.6060}\, DVIta_{it} + \underset{(0.09)}{0.0129}\, DVJpn_{it} - \underset{(0.77)}{0.2075}\, DVNor_{it} - \underset{(2.34)}{0.3066}\, DVUK_{it}
\end{aligned}$$

$R^2 = 0.64$, $AdjR^2 = 0.59$, $S.E.E. = 0.141$, $n = 180$

$$\begin{aligned}
\ln(c_{it}/c_t) &= -\underset{(5.45}{0.2482} + \underset{(4.80)}{0.4778} \ln[(y_{it}^N - g_{it}^N)/(y_t^N - g_t^N)] + \underset{(7.30)}{0.2164} \ln(g_{it}/g_t) \\
&- \underset{(2.59)}{0.0030}\, TrendAus_{it} - \underset{(1.50)}{0.0027}\, TrendCan_{it} - \underset{(8.20)}{0.0123}\, TrendDen_{it} \\
&- \underset{(2.23)}{0.0039}\, TrendFin_{it} - \underset{(4.66)}{0.0055}\, TrendFra_{it} - \underset{(4.07)}{0.0046}\, TrendGre_{it} \\
&+ \underset{(3.61)}{0.0035}\, TrendIta_{it} + \underset{(0.04)}{0.0001}\, TrendJpn_{it} - \underset{(2.28)}{0.0042}\, TrendNor_{it} \qquad (25) \\
&+ \underset{(0.99)}{0.0016}\, TrendUK_{it} + \underset{(8.20)}{0.2542}\, DVCan_{it} + \underset{(4.99)}{0.4434}\, DVDen_{it}
\end{aligned}$$

$$+ \underset{(1.24)}{0.0592}\, DVFin_{it} + \underset{(5.72)}{0.4849}\, DVFra_{it} + \underset{(4.05)}{1.6019}\, DVGre_{it}$$

$$+ \underset{(4.02)}{0.2799}\, DVIta_{it} + \underset{(2.54)}{0.0500}\, DVJpn_{it} + \underset{(3.22)}{0.2048}\, DVNor_{it} + \underset{(1.00)}{0.0309}\, DVUK_{it}$$

$R^2 = 0.99$, $AdjR^2 = 0.98$, $S.E.E. = 0.027$, $n = 180$

Absolute values of t-statistics are in parentheses and S.E.E. is the standard error of the regression.

The results indicate that relative per capita nontradables output has the expected negative relationship with the real exchange rate in (24) and expected positive relationship with relative per capita consumption in (25). Relative per capita government consumption has a positive relationship with both the real exchange rate and relative per capita private consumption, suggesting that government consumption *complements* private consumption via the consumption-tilting channel. However, as discussed earlier, indirect least squares cannot identify uniquely structural parameters because of overidentification. Equation (25) is used in the first stage of 2SLS to generate the instrument, denoted pvln(c_{it}/c_t), used in the next section.

B. Structural Equations

Two-stage least squares estimation of equations (22) and (23)—with the restriction that the slope coefficient estimates in intratemporal equilibrium condition (22) be equal but oppositely signed (consistent with the model)—yields:

$$\ln x_{it} = \underset{(50.20)}{4.8636} + \underset{(2.15)}{1.2008}\, \text{pvln}(c_{it}/c_t) - \underset{(2.15)}{1.2008}\, \ln[(y_{it}^N - g_{it}^N)/(y_t^N - g_t^N)]$$

$$- \underset{(2.45)}{0.3705}\, DVCan_{it} - \underset{(1.66)}{0.8452}\, DVDen_{it} - \underset{(1.02)}{0.1730}\, DVFin_{it}$$

$$- \underset{(2.03)}{1.0233}\, DVFra_{it} - \underset{(2.28)}{4.4972}\, DVGre_{it} - \underset{(2.71)}{0.9774}\, DVIta_{it} \qquad (26)$$

$$+ \underset{(1.29)}{0.1017}\, DVJpn_{it} - \underset{(1.31)}{0.3865}\, DVNor_{it} - \underset{(3.19)}{0.4051}\, DVUK_{it}$$

$R^2 = 0.53$, $AdjR^2 = 0.50$, $S.E.E. = 0.156$, $n = 180$

$$
\begin{aligned}
\ln x_{it} = {} & \underset{(9.70)}{3.9375} - \underset{(2.18)}{1.7638}\ \mathrm{pvln}(c_{it}/c_t) + \underset{(2.96)}{0.7396} \ln(g_{it}/g_t) \\
& + \underset{(0.37)}{0.0035}\ TrendAus_{it} - \underset{(3.16)}{0.0150}\ TrendCan_{it} - \underset{(1.80)}{0.0281}\ TrendDen_{it} \\
& - \underset{(0.20)}{0.0022}\ TrendFin_{\mathrm{it}} - \underset{(0.77)}{0.0066}\ TrendFra_{it} - \underset{(3.62)}{0.0293}\ TrendGre_{it} \\
& + \underset{(0.95)}{0.0102}\ TrendIta_{it} + \underset{(3.34)}{0.0326}\ TrendJpn_{it} - \underset{(0.54)}{0.0052}\ TrendNor_{it} \qquad (27) \\
& + \underset{(1.12)}{0.0071}\ TrendUK_{it} + \underset{(2.24)}{0.5963}\ DVCan_{it} + \underset{(1.99)}{0.2895}\ DVDen_{it} \\
& - \underset{(0.27)}{0.0485}\ DVFin_{it} + \underset{(1.83)}{0.2772}\ DVFra_{it} - \underset{(0.74)}{0.2324}\ DVGre_{it} \\
& - \underset{(0.98)}{0.1124}\ DVIta_{it} + \underset{(0.71)}{0.1011}\ DVJpn_{it} + \underset{(1.10)}{0.1538}\ DVNor_{it} - \underset{(2.02)}{0.2521}\ DVUK_{it}
\end{aligned}
$$

$R^2 = 0.64$, $AdjR^2 = 0.59$, $S.E.E. = 0.141$, $n = 180$

Absolute values of t-statistics are again in parentheses.

The 2SLS estimation of the intratemporal and intertemporal equilibrium conditions suggests the following inferences regarding government expenditures, in the context of the model. Equation (26) implies that an increase in home government purchases of nontradables creates excess demand for nontradables. This has the effect of withdrawing resources from private nontradables consumption and raising the relative price of (private consumption) nontradables to tradables, causing a real appreciation of the home currency; this is the resource-withdrawal effect. Additionally, equation (27) implies that an increase in per capita government expenditure raises the marginal utility of home private consumption, raising both home per capita private consumption and the home relative price of nontradables to tradables, causing a real appreciation of the home currency. The positive estimate of suggests that government consumption and private consumption are *complements*; the estimate of □ (0.7396) is statistically significantly different from zero at the 1 percent level.

The 2SLS estimation of the intratemporal and intertemporal equilibrium conditions yields the following inferences of the model's other parameters. The estimated inverse of the elasticity of intertemporal substitution (or the coefficient of relative risk aversion), □, equals 1.76. This estimate is consistent with those in the closed-economy macroeconomics literature; estimates of □ range typically between 0 and 2. This estimate is statistically significantly different from zero at the 5 percent level.

The estimate of □ is 1.2; this coefficient is statistically significant at the 5 percent level. The equation was estimated also with the restriction relaxed. Using a χ^2 statistic, equality of the two coefficients in intratemporal condition (26), allowing for the sign difference, could not be rejected at the 5 percent significance level (χ^2=1.14 compared to critical value χ^2[0.95;1]=3.84). This estimate of implies a share of nontradables in the period Cobb-Douglas utility function of 0.55, which is quite plausible.

The estimated values of relative discount rates, $\square_i/\square$, in equation (27) range between -3 percent for Greece and 3 percent for Japan. The estimates suggest that the US rate of time preference is not notably greater than that of several other OECD countries. However, the results suggest that the United States was economically and statistically significantly *more* thrifty than Canada and Greece, over the period examined, but economically and statistically *less* thrifty than Japan.

C. Relative Effects of Government Expenditure Consumption Tilting vs. Resource Withdrawal

The parameter estimates in equations (26) and (27) allow us to estimate the relative importance of the resource-withdrawal versus consumption-tilting effects of government expenditure on real exchange rates. To illustrate the relative effects for a one percent increase in the home country's (US) government purchases of nontradables (g^N_t), consider theoretical real exchange rate equation (20). Differentiating equation (20) with respect to g^N_t yields:

$$d \ln x_{it} = \square\, [\square\square/(\square + \square)]\, d \ln[1/(\square^N_t \,\square\, g_t^N)] \;+\; [\square\square/(\square + \square)]\, d \ln(1/g_t) \qquad (28)$$

Recalling equation (3), assume government consumption is a Cobb-Douglas function of government nontradables and government tradables, where denotes the share of nontradables in government consumption. Then equation (28) becomes:

$$dx_{it}/x_{it} = \square\, [\square\square/(\square + \square)][g_t^N/(y_t^N \,\square\, g_t^N)]\, dg_t^N/g_t^N \;-\; \square[\square\square/(\square + \square)]\, dg_t^N/g_t^N \qquad (29)$$

The first (second) term on the RHS represents the resource-withdrawal (consumption-tilting) effect of a one percent increase in home government purchases of nontradables. To evaluate the contribution of the first term, an estimate of $g^N_t/(y^N_t-g^N_t)$ is needed and to evaluate the second term an estimate of $\square$ is needed. Such data is not available for any country in either Summers and Heston (1991) or OECD *Annual National Accounts* (1996). However, the US National Income and Product Accounts decompose government and private consumption expenditures into goods and services, which is used typically to approximate the decomposition into tradables and nontradables. For the United States, $g^N_t/(y^N_t-g^N_t)$ equals 0.43 and $\square$ equals 0.77, averaged over our time period of 1970–1988. Substituting these values into equation (29), along with the parameter estimates of $\square\square/(\square+\square)$ and $\square\square/(\square+\square)$ yields:

$$dx_{it}/x_{it} = -0.3624\, dg_t^N/g_t^N - 0.2755\, dg_t^N/g_t^N \qquad (30)$$

Equation (30) indicates that the estimated magnitude of the resource-withdrawal effect on the real exchange rate of a one percent increase in US government purchases of nontradables is only slightly greater than the consumption-tilting effect.

If a US government consumption increase of one percent is proportionate across nontradables *and* tradables, the theoretical effect on the real exchange is:

$$dx_{it}/x_{it} = -\, [\square\square/(\square + \square)][g_t^N/(y_t^N - g_t^N)]\, dg_t/g_t \,\square\, [\square\square/(\square + \square)]\, dg_t/g_t \qquad (31)$$

Substituting into equation (31) the appropriate parameter estimates yields:

$$dx_{it} / x_{it} = \; -0.3624 \, dg_t/g_t - 0.3578 \, dg_t / g_t \tag{32}$$

In the case of proportionate increases in US government tradables and nontradables consumption, a one percent increase in government consumption appreciates the dollar by roughly 0.7 of one percent; the source of the dollar's real appreciation is estimated to be attributable *approximately equally* to the consumption-tilting and resource-withdrawal channels.

IV. Conclusions

The NBER *Reporter* noted not too long ago that:

> One of the recent areas of resurgent research in open economy macroeconomics has been the examination of real exchange rates….Chinn and Johnston find that government spending and productivity trends help in the analysis of real exchange rates; their finding is confirmed by Canzoneri, Cumby, and Diba, and by De Gregorio and Wolf (Rose, 1997, 1–2).

This paper has extended the intertemporal neoclassical framework for a small open economy in Frenkel and Razin (1996) to examine theoretically and empirically the "resource-withdrawal" versus "consumption-tilting" effects of government expenditure on real exchange rates. Closed-form theoretical solutions from a two-country, stochastic, dynamic, general equilibrium model illustrated the effect of government expenditure on private consumption decisions through intratemporal and intertemporal channels.

Empirical evaluation of the model using panel data from the UN Income Comparisons Program and OECD (1996) provides evidence that a per capita government expenditure increase may be causing a real appreciation of a country's currency via resource withdrawal in the medium run. Simultaneously, the same government spending increase may cause the country's currency to appreciate in real terms because government consumption complements the utility from private consumption. Moreover, these effects are found in the context of plausible parameter estimates of the countries' representative consumers' elasticities of intertemporal substitution, relative rates of time preference, and shares of nontradables in utility. The empirical results suggest that the potential importance of the consumption-tilting channel should not be ignored since this channel has roughly an equal effect on the real exchange rate as the resource-withdrawal channel.

The extant literature on real exchange rates has traditionally perceived the real appreciation of a country's currency as a cost necessarily incurred to benefit from the provision of public goods, interpreted typically as the opportunity cost of *foregone* private consumption (notably of nontradables private consumption). Our framework and empirical results suggest that the associated real appreciation of a country's currency in response to increased public consumption can be interpreted partially as the shadow price of a benefit to the representative agent's utility from the complementarity of government and private consumption. This suggests reconsidering the relative benefits of public expenditures and their implications for explaining departures from purchasing power parity.

Endnotes

[1] Throughout we are concerned with government spending, not fiscal policy. Government spending is financed here by lump-sum taxes. Since Ricardian equivalence holds in our context, budget deficits related to the timing of taxation are not relevant here.

[2] Penati (1987) addressed government spending (potentially on tradables and nontradables) and equilibrium real exchange rates in an intertemporal neoclassical theoretical model, but similarly focused only upon the resource-withdrawal channel. His paper did not provide empirical investigation.

[3] Since the production processes are exogenous, the consumers take outputs as givens (and factors are fixed). The exogenous output structure suggests a model that explains medium-run, rather than long-run, real exchange rate behavior. As discussed in Obstfeld and Rogoff (1996, Chapter 4), long-run equilibrium real exchange rates should be determined by supply-side factors alone, as suggested by the Balassa-Samuelson hypothesis; relative government expenditures and other relative demand shocks should not matter with homothetic preferences in the long run. However, with exogenous outputs, relative government expenditures will affect equilibrium real exchange rates in the medium run. This is consistent with empirical studies, such as De Gregorio, Giovannini and Wolf (1994), where government expenditures had short-run, but not long-run, effects on real exchange rates.

[4] Given the CRRA utility and perfect capital mobility assumptions, it can be shown that the existence of claims for all production sectors, representing shares in the stochastic endowment processes, is sufficient to effectively complete markets in our model.

[5] Note that $\square$ depends on initial relative wealth of the two consumers and the exogenous processes for government expenditures. Our formulation, in which the social planner chooses private expenditure but not public expenditure, may appear paradoxical. However, it corresponds to a market outcome for the standard case where individuals choose their consumption subject to exogenously determined government expenditure.

[6] The tradable good may serve as the numeraire in both countries, implying $e_t = 1$ in equation (10). If money is introduced explicitly—for instance, via a binding cash-in-advance constraint, $m_t = p_t\ c_t$ (and analogously abroad)—then the prices of the tradable goods will be determined within the model and the exchange rate can have any positive value, in principle.

[7] Note that the intertemporal equilibrium condition is neither stochastic nor explicitly dynamic. Although the model is derived in a stochastic setting, the assumption of complete markets implies optimal risk sharing so that *relative* prices and *relative* consumption levels are deterministic. Moreover, the dynamic Euler equation linking the marginal rates of intertemporal substitution of the representative consumers to intertemporal price ratios in a market economy can be converted to the static version of equation (17) when couched in the relative consumption allocations assigned by a social planner.

[8] The reader familiar with the Balassa-Samuelson hypothesis may be concerned in equation (18) over the omission of relative tradables productivity levels. However, the productivity-differentials theory of Balassa and Samuelson is imbedded in our intratemporal equilibrium. In his analysis, Balassa (1964) assumes "invisibles and capital movements do not enter the balance of payments," thus avoiding the relevance of the intertemporal equilibrium. It follows that the trade balance must be assumed equal to zero so that not only $y^N_t=c^N_t$ but also $y^T_t=c^T_t$. Combining equations (7) and (15), assuming no government expenditures, with market clearing produces:

$$x_t = [(y^{T}{}_t{}^{*}/y^{N}{}_t{}^{*})/(y^T{}_t/y^N{}_t)]^{\square/(1+\square)}$$

which is the Balassa-Samuelson relationship.

[9] The ten other OECD countries are Austria, Canada, Denmark, Finland, France, Greece, Italy, Japan, Norway, and the United Kingdom. In the work of Kravis, Heston and Summers on the ICP, nontradables (tradables) are identical to services (commodities) in private final consumption expenditures. Estimation of the econometric analogues to equations (15), (18), and (19) requires data on $(y^{N*}-g^{N*})/(y^N-g^N)$. OECD *Annual National Accounts* does not provide any data on the decomposition of government expenditure

between tradables and nontradables, and the decompositions for real GDP are limited and for short time periods. However, OECD data does decompose private consumption expenditures between services (nontradables) and goods (tradables). Estimation of equations (15), (18), and (19) only requires data on relative nontradables consumption, since $y^N - g^N = c^N$ (and analogously abroad) in the context of the model.

[10] As the previous footnote addressed, due to data limitations $(y_{it}^N-g_{it}^N)/(y_t^N-g_t^N)$ is measured by c_{it}^N/c_t^N. However, due to the potential endogeneity of this RHS variable, c_{it}^N/c_t^N is replaced by an instrument created from its lagged value and a constant. Although a Hausman specification test did not indicate evidence of endogeneity, the results presented in this paper use the instrument to ensure that this RHS variable is predetermined. Results using c_{it}^N/c_t^N (instead of the instrument) provide a similar fit and the coefficient estimates are not materially different. The latter results are omitted here for brevity, but are available upon request.

[11] For econometric convenience, we use an intercept and 9 dummy variables.

[12] As noted earlier, data was available for these variables for the period 1953–1988. Data was available for relative nontradables consumption levels only for the much shorter period 1973–1988. Since the unit root tests for the shorter period for all variables would have had a time dimension (with necessary lags) of only 12 periods, we considered this time dimension too short to benefit from the power of the Levin-Lin tests. Consequently, we chose to conduct the unit root tests for all the variables except relative nontradables consumption for the longer period of 1953–1988. The results are for tests where the test statistics are asymptotically normally distributed. We did not include tests with individual fixed effects; these effects were statistically insignificant.

[13] For the relative price variable, the null hypothesis could only be rejected at the 10 percent significance level when only an intercept was added.

[14] For instance, dividing the coefficient for country 1's time trend in equation (20), {[□/(□+□)][ln(□$_1$/□]}, by the coefficient for this time trend in equation (21), {[1/(□+□)][ln(□$_1$/□]}, yields identification of □. However, dividing the coefficient for country 2's (or 3's, etc.) time trend in equation (20), {[□/(□+□)][ln(□$_2$/□]}, by the coefficient for this time trend in equation (21), {[1/(□+□)][ln(□$_2$/□]}, yields identification of □ also. Thus, using indirect least squares with the reduced forms cannot identify uniquely □ or any of the 10 country pairings' relative discount rates.

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Table 1

Tests for Nonstationarity of Relative Price Levels Using Panel Data and Levin-Lin (1992)

Model	$\square_0$ Estimate	t-statistic	10% (5%) Critical t	Null Hypothesis of Nonstationarity[1]
1a. $\square y_{it} = (\square_0 - 1)\, y_{it-1} + \square_t$	–0.04	–2.68	–1.44 (–1.81)	Reject (Reject)
1b. $\square y_{it} = (\square_0 - 1)\, y_{it-1} + \square_1 \square y_{it-1} + \square_t$	–0.06	–3.88	–1.44 (–1.81)	Reject (Reject)
1c. $\square y_{it} = (\square_0 - 1)\, y_{it-1} + \square_1 \square y_{it-1} + \square_2 \square y_{it-2} + \square_t$	–0.06	–3.69	–1.44 (–1.81)	Reject (Reject)
2a. $\square y_{it} = \square_0 + (\square_0 - 1)\, y_{it-1} + \square_t$	–0.03	–1.91	–1.72 (–2.09)	Reject (Not Reject)
2b. $\square y_{it} = \square_0 + (\square_0 - 1)\, y_{it-1} + \square_1 \square y_{it-1} + \square_t$	–0.05	–3.35	–1.72 (–2.09)	Reject (Reject)
2c. $\square y_{it} = \square_0 + (\square_0 - 1)\, y_{it-1} + \square_1 \square y_{it-1} + \square_2 \square y_{it-2} + \square_t$	–0.05	–3.08	–1.72 (–2.09)	Reject (Reject)
3a. $\square y_{it} = \square_0 + \square_1 t + (\square_0 - 1)\, y_{it-1} + \square_t$	–0.07	–3.85	–2.01 (–2.39)	Reject (Reject)
3b. $\square y_{it} = \square_0 + \square_1 t + (\square_0 - 1)\, y_{it-1} + \square_1 \square\, y_{it-1} + \square_t$	–0.10	–5.33	–2.01 (–2.39)	Reject (Reject)
3c. $\square y_{it} = \square_0 + \square_1 t + (\square_0 - 1)\, y_{it-1} + \square_1 y_{it-1} + \square_2 y_{it-2} + \square_t$	–0.10	–5.06	–2.01 (–2.39)	Reject (Reject)
4a. $\square y_{it} = (\square_0 - 1)\, y_{it-1} + v_t + \square_t$	–0.04	–2.89	–2.01 (–2.39)	Reject (Reject)
4b. $\square y_{it} = (\square_0 - 1)\, y_{it-1} + \square_1 y_{it-1} + \square_t + \square_t$	–0.05	–3.06	–2.01 (–2.39)	Reject (Reject)
4c. $\square y_{it} = (\square_0 - 1)\, y_{it-1} + \square_1 \square y_{it-1} + \square_2 \square y_{it-2} + v_t + \square_t$	–0.04	–3.00	–2.01 (–2.39)	Reject (Reject)

[1]At the 10% (5%) significance level.

Table 2

Tests for Nonstationarity of Relative Per Capita Consumption Levels Using Panel Data and Levin-Lin (1992)

Model	$\square_0$ Estimate	t-statistic	10% (5%) Critical t	Null Hypothesis of Nonstationarity[1]
1a. $\square y_{it} = (\square_0 -1)\ y_{it-1} + \square_t$	-0.02	-9.55	-1.44 (-1.81)	Reject (Reject)
1b. $\square y_{it} = (\square_0 -1)\ y_{it-1} + \square_1 \square y_{it-1} + \square_t$	-0.02	-7.74	-1.44 (-1.81)	Reject (Reject)
1c. $\square y_{it} = (\square_0 -1)\ y_{it-1} + \square_1\ y_{it-1} + \square_2\ y_{it-2} + \square_t$	-0.02	-6.98	-1.44 (-1.81)	Reject (Reject)
2a. $\square y_{it} = \square_0 + (\square_0 -1)\ y_{it-1} + \square_t$	-0.03	-7.43	-1.72 (-2.09)	Reject (Reject)
2b. $\square y_{it} = \square_0 + (\square_0 -1)\ y_{it-1} + \square_1 \square y_{it-1} + \square_t$	-0.03	-6.64	-1.72 (-2.09)	Reject (Reject)
2c. $\square y_{it} = \square_0 + (\square_0 -1)\ y_{it-1} + \square_1 \square y_{it-1} + \square_2 \square y_{it-2} + \square_t$	-0.03	-6.39	-1.72 (-2.09)	Reject (Reject)
3a. $\square y_{it} = \square_0 + \square_1\ t + (\square_0 -1)\ y_{it-1} + \square_t$	-0.03	-6.25	-2.01 (-2.39)	Reject (Reject)
3b. $\square y_{it} = \square_0 + \square_1\ t + (\square_0 -1)\ y_{it-1} + \square_1 \square y_{it-1} + \square_t$	-0.03	-5.74	-2.01 (-2.39)	Reject (Reject)
3c. $\square y_{it} = \square_0 + \square_1\ t + (\square_0 -1)\ y_{it-1}$ $+ \square_1\ y_{it-1} + \square_2 \square y_{it-2} + \square_t$	-0.03	-5.66	-2.01 (-2.39)	Reject (Reject)
4a. $\square y_{it} = (\square_0 -1)\ y_{it-1} + v_t + \square_t$	-0.03	-7.10	-2.01 (-2.39)	Reject (Reject)
4b. $\square y_{it} = (\square_0 -1)\ y_{it-1} + \square_1 \square y_{it-1} + v_t + \square_t$	-0.03	-6.10	-2.01 (-2.39)	Reject (Reject)
4c. $\square y_{it} = (\square_0 -1)\ y_{it-1} + \square_1 \square y_{it-1}$ $+ \square_2 \square y_{it-2} + v_t + \square_t$	-0.03	-5.84	-2.01 (-2.39)	Reject (Reject)

[1]At the 10% (5%) significance level.

Table 3

Tests for Nonstationarity of Relative Per Capita Government Consumption Levels Using Panel Data and Levin-Lin (1992)

Model	$\square_0$ Estimate	t-statistic	10% (5%) Critical t	Null Hypothesis of Nonstationarity[1]
1a. $\square y_{it} = (\square_0\text{-}1)\ y_{it-1} + \square_t$	-0.03	-12.66	-1.44 (-1.81)	Reject (Reject)
1b. $\square y_{it} = (\square_0\text{-}1)\ y_{it-1} + \square_1\ \square y_{it-1} + \square_t$	-0.02	-9.38	-1.44 (-1.81)	Reject (Reject)
1c. $\square y_{it} = (\square_0\text{-}1)\ y_{it-1} + \square_1\ \square y_{it-1}$ $+ \square_2\ \square y_{it-2} + \square_t$	-0.02	-8.94	-1.44 (-1.81)	Reject (Reject)
2a. $\square y_{it} = \square_0 + (\square_0\text{-}1)\ y_{it-1} + \square_t$	-0.02	-4.32	-1.72 (-2.09)	Reject (Reject)
2b. $\square y_{it} = \square_0 + (\square_0\text{-}1)\ y_{it-1} + \square_1\ \square y_{it-1} + \square_t$	-0.02	-4.37	-1.72 (-2.09)	Reject (Reject)
2c. $\square y_{it} = \square_0 + (\square_0\text{-}1)\ y_{it-1}$ $+ \square_1\ \square y_{it-1} + \square_2\ \square y_{it-2} + \square_t$	-0.02	-3.86	-1.72 (-2.09)	Reject (Reject)
3a. $\square y_{it} = \square_0 + \square_1\ t + (\square_0\text{-}1)\ y_{it-1} + \square_t$	-0.02	-3.37	-2.01 (-2.39)	Reject (Reject)
3b. $\square y_{it} = \square_0 + \square_1\ t + (\square_0\text{-}1)\ \square y_{it-1}$ $+ \square_1\ y_{it-1} + \square_t$	-0.02	-3.27	-2.01 (-2.39)	Reject (Reject)
3c. $\square y_{it} = \square_0 + \square_1\ t + (\square_0\text{-}1)$ $y_{it-1} + \square_1\ \square y_{it-1} + \square_2\ \square y_{it-2} + \square_t$	-0.01	-3.18	-2.01 (-2.39)	Reject (Reject)
4a. $\square y_{it} = (\square_0\text{-}1)\ y_{it-1} + v_t + \square_t$	-0.02	-5.11	-2.01 (-2.39)	Reject (Reject)
4b. $\square y_{it} = (\square_0\text{-}1)\ y_{it-1} + \square_1\ \square y_{it-1} + v_t + \square_t$	-0.01	-4.61	-2.01 (-2.39)	Reject (Reject)
4c. $\square y_{it} = (\square_0\text{-}1)\ y_{it-1} + \square_1\ \square y_{it-1}$ $+ \square_2\ \square y_{it-2} + v_t + \square_t$	-0.01	-4.62	-2.01 (-2.39)	Reject (Reject)

[1]At the 10% (5%) significance level.