CHAPTER 7

National Price Level

7.1 The National Price Level: Theory and Estimation

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The national price level—defined as the ratio of the domestic country's price level expressed in base-country currency to the base-country's price level, or, equivalently, the ratio of purchasing power parity (PPP) to the exchange rate—has developed a literature of its own in the 1980s. Work has flourished in every aspect: (a) data generation (principally, the International Comparison Project [ICP], with Phase 3 published as Kravis et al. [1982], and Phases 4 and 5 continuing at the United Nations); (b) use of the national price level in short-cut estimation of real income for international comparison (for example, Isenman 1980; Clague 1986b); (c) theoretical analysis (especially Kravis and Lipsey 1983; Bhagwati 1984; Clague 1985, 1986c); and (d) econometric explanation (for example, Salazar-Carrillo 1982b; Clague 1986a, 1988a, b; Kravis and Lipsey 1987).

This paper shows that the existing literature suffers uniformly from methodological and econometric problems, and attempts to correct these defects. The approach is to take seriously the assumptions and

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implications of the accepted theory of the national price level, contrary to the practice of practitioners in the field. The state of the art is improved by deriving the analytical relationship between the national price level and the nontradable/tradable price-level ratio as it varies with the specific PPP index-number concept, and then making use of this relationship in econometric estimation of the national price level.

7.1.1 Conventional Approach to the National Price Level

Consider the following notation:

PL = national price level, ratio of price level of domestic country expressed in base-country currency to price level of base country, dimensionless
PPP = purchasing power parity for gross domestic product (GDP), number of units of domestic currency per unit of base-country currency
R = exchange rate, number of units of domestic currency per unit of base-country currency
Y_{jk} = GDP of country j valued at prices of country k;
b = base country
d = domestic country.

Then, by definition,

$$\text{PL} = \text{PPP}/R. \tag{7.1}$$

The term "national price level" emanates from the equivalent definition of PL as the ratio of "nominal" to "real" income, that is, the ratio of GDP converted to base-country currency via the exchange rate (sometimes called "conventional income") to GDP converted to base-country currency via PPP ("real income"):

$$\text{PL} = (Y_{dd}/R)/Y_{db},$$

where

$$Y_{db} = Y_{dd}/\text{PPP}. \tag{7.2}$$

The conventional approach to explaining the national price level follows a three-step process, but the literature does not formalize the procedure. Three propositions are involved. First, all commodities are divided into two sharply defined classes: tradables and nontradables (sometimes loosely designated as goods and services, respectively).[1] Therefore

$$Y_{jj} = \mathrm{YT}_j + \mathrm{YN}_j, \quad j = b, d; \tag{7.3}$$

where YT_j (YN_j) denotes the output of tradables (nontradables) of country j valued at prices of country j.

Second, the "law of one price" for tradables is imposed, that is, the price level of tradables expressed in a common currency is equalized in the domestic and base countries.[2] Letting PT (PN) denote the ratio of the price level of tradables (nontradables) in the domestic country to that in the base country, the law of one price for tradables is

$$\mathrm{PT} = R. \tag{7.4}$$

Third, the principal influences on the national price level are deemed to be long run or structural, and to operate through affecting the ratio of the nontradable to the tradable price level in the domestic country relative to the base country, that is, the nontradable/tradable price-level ratio, P, defined as

$$P = \mathrm{PN}/\mathrm{PT}. \tag{7.5}$$

Because the nontradable/tradable price-level ratio, P, and the national price level, PL, are positively related, the explanatory variables for P are ultimate determinants of PL with the same directional effect.[3]

Accepting propositions one and two, as well as proposition three to the extent it is consistent with the first two, one can show that the literature suffers from a variety of limitations:

1. The third proposition of the approach (that long-term determinants of the national price level operate through the nontradable/tradable price-level ratio) does not necessarily follow from the second proposition (the law of one price for tradables). Indeed, the third proposition does not always apply.

2. Short-run (monetary) determinants of the national price level are considered in both theory and econometric testing. Yet such variables can enter the analysis only tenuously compared to long-run (structural) variables.
3. While hypothesis specification for long-run explanatory variables directly concerns the impact of these variables on the nontradable/tradable price-level ratio (P), econometric estimation invariably uses the national price level (PL) as the dependent variable. True, PL is the variable of interest; however, direct hypothesis testing requires an equation in which P is the dependent variable.[4]
4. There is an analytical relationship between P and PL that depends on the specific index selected for PPP. This relationship is not derived or even mentioned in the literature, and therefore it is ignored—and sometimes contradicted—in econometric estimation of the national price level.
5. The analytical relationship between P and PL has implications for hypothesis specification for PL beyond the explanatory variables operating through P. Consistent with point one, the relationship can stipulate long-run explanatory variables for a PL regression quite apart from the P route, a phenomenon alien to the existing literature.
6. The fact that there is an analytical expression for PL in terms of P and (depending on the index selected) other variables implies that conventional econometric estimation of PL, which confines itself to linear or log-linear functional form, is generally incorrect, as the PL-P analytical expression is inherently nonlinear for most PPP measures.
7. Existing empirical studies make no effort to delineate the relative importance of explanatory variables for PL. Rather, it is *assumed* that real per capita income is the variable with greatest impact on PL.

How could deficiencies of this magnitude exist in an established body of literature? The reason is twofold. First, practitioners in the field have not applied index-number algebra to their body of theory in a general way, even though purchasing power parity (by definition, the numerator of the national price level) is inherently an index number. Second, practitioners do not take seriously the three propositions that they explicitly adopt as the basis for theorizing about the national price level, and

therefore have not carried the implications of these propositions to their logical conclusions.

7.1.2 *The Various PPP Indexes*

Let ST_j (SN_j) denote the share of tradables (nontradables) in the output of country j, defined as follows:

$$\mathrm{ST}_j = \mathrm{YT}_j / Y_{jj}, \quad j = b, d; \tag{7.6}$$

$$\mathrm{SN}_j = \mathrm{YN}_j / Y_{\mathrm{jj}}, \quad j = b, d; \tag{7.7}$$

From (7.3), it follows that

$$\mathrm{ST}_j = 1 - \mathrm{SN}_j, \quad j = b, d. \tag{7.8}$$

Applying proposition one of the conventional approach (a tradable/nontradable dichotomy of output and therefore price) and a two-country model (the base country and only one domestic country), well-known PPP indexes are the Laspeyres, Paasche, Fisher ideal, Walsh, and Geary-Khamis, with the following definitions.[5]

$$\text{Laspeyres: } \mathrm{PPP} = \mathrm{ST}_b \cdot \mathrm{PT} + \mathrm{SN}_b \cdot \mathrm{PN}. \tag{7.9}$$

$$\text{Paasche: } \mathrm{PPP} = \frac{1}{\mathrm{ST}_d/\mathrm{PT} + \mathrm{SN}_d/\mathrm{PN}}. \tag{7.10}$$

$$\text{Fisher: } \mathrm{PPP} = \left(\frac{\mathrm{ST}_b \cdot \mathrm{PT} + \mathrm{SN}_b \cdot \mathrm{PN}}{\mathrm{ST}_d/\mathrm{PT} + \mathrm{SN}_d/\mathrm{PN}} \right)^{1/2}. \tag{7.11}$$

The variables PPP, PT, and PN are specific to each index. The Laspeyres PPP (and PT, PN) is the sum of domestic-country/base-country price relatives, each weighted by the base-country output share; while the Paasche PPP (and PT, PN) is the inverse of the sum of base-country/domestic-country price relatives, each weighted by the domestic-country output share. The Fisher ideal index is the geometric mean of the Laspeyres and Paasche indexes.

The general form of the Walsh index is

$$\text{Walsh: } \mathrm{PPP} = \mathrm{PT}^{\mathrm{WT}} \cdot \mathrm{PN}^{\mathrm{WN}}, \tag{7.12}$$

where

$$\mathrm{WT} = 1 - \mathrm{WN}. \tag{7.13}$$

The Walsh index with arithmetic-mean weights is the product of domestic-country/base-country price relatives, each weighted exponentially by the arithmetic mean of the countries' output shares:

$$\mathrm{WT} = (\mathrm{ST}_b + \mathrm{ST}_d)/2,$$

$$\mathrm{WN} = (\mathrm{SN}_b + \mathrm{SN}_d)/2.$$

The Walsh index with geometric-mean weights is the product of domestic-country/base-country price relatives, each weighted exponentially by the geometric mean of the countries' output shares; the means are normalized so that (7.13) is satisfied:

$$\mathrm{WT} = \frac{(\mathrm{ST}_b \cdot \mathrm{ST}_d)^{1/2}}{(\mathrm{ST}_b \cdot \mathrm{ST}_d)^{1/2} + (\mathrm{SN}_b \cdot \mathrm{SN}_d)^{1/2}},$$

$$\mathrm{WN} = \frac{(\mathrm{SN}_b \cdot \mathrm{SN}_d)^{1/2}}{(\mathrm{ST}_b \cdot \mathrm{ST}_d)^{1/2} + (\mathrm{SN}_b \cdot \mathrm{SN}_d)^{1/2}},$$

$$\text{Geary-Khamis: } \mathrm{PPP} = \frac{1}{\mathrm{ST}_d \cdot (\mathrm{PT}_I/\mathrm{PT}) + \mathrm{SN}_d \cdot (\mathrm{PN}_I/\mathrm{PN})}, \tag{7.14}$$

where $\mathrm{PT}_I(\mathrm{PN}_I)$ is the ratio of international price level of tradables (nontradables) to price level of tradables (nontradables) in the base country.

The Geary-Khamis PPP is a Paasche index with the base country replaced by the (two-country) world, as $\mathrm{PT}_I/\mathrm{PT}$ and $\mathrm{PN}_I/\mathrm{PN}$ are international/domestic-country price relatives. This index is expressed, along with the other PPP indexes, as the number of units of domestic currency per unit of base-country currency; because PPP for the base country (the base-country/international PPP) is identically equal to unity.[6]

$$\mathrm{PT}_I = \frac{\mathrm{YT}_d/\mathrm{PPP} + \mathrm{YT}_b}{\mathrm{YT}_d/\mathrm{PT} + \mathrm{YT}_b} \tag{7.15}$$

$$\mathrm{PN}_I = \frac{\mathrm{YN}_d/\mathrm{PPP} + \mathrm{YN}_b}{\mathrm{YN}_d/\mathrm{PN} + \mathrm{YN}_b} \tag{7.16}$$

The international/base-country price level of tradables (nontradables) is the ratio of the sum of domestic-country and base-country output at international prices to the sum at base-country prices. There is an asymmetry in that there is only one international-currency/domestic-currency conversion factor (1/PPP) and it pertains to all output (as does the international-currency/base-currency conversion factor, unity), whereas the base-currency/domestic-currency conversion factor (1/PT or 1/PN) is specific to tradables or nontradables.

Equations (7.14), (7.15), and (7.16) constitute a system to be solved simultaneously for PPP, PT_I, and PN_I. The variable that is of interest, PPP, is the one positive root of the following quadratic:

$$\mathrm{A} \cdot PPP^2 + \mathrm{B} \cdot PPP + C = 0; \tag{7.17}$$

where

$$\begin{aligned} A &= \mathrm{ST}_d \cdot \mathrm{SN}_d \cdot Y/\mathrm{PT}, \\ B &= \mathrm{ST}_d \cdot \mathrm{ST}_b \cdot \mathrm{SN}_b \cdot P + \mathrm{ST}_b \cdot \mathrm{SN}_d \cdot \mathrm{SN}_b \\ &\quad - \mathrm{ST}_d \cdot \mathrm{SN}_d \cdot \mathrm{SN}_b \cdot Y \cdot P - \mathrm{ST}_d \cdot \mathrm{ST}_b \cdot \mathrm{SN}_d \cdot Y, \\ C &= -\mathrm{ST}_b \cdot \mathrm{SN}_b \cdot \mathrm{PN}, \\ Y &= Y_{db}/Y_{bb}. \end{aligned}$$

7.1.3 *Issues of Theory and Estimation*

First issue: What is the analytical expression for the national price level, PL, in terms of the nontradable/tradable price-level ratio, P, assuming the law of one price for tradables?

For the Laspeyres, Paasche, Fisher, and Walsh indexes, the answer is obtained by taking Eq. (7.1), PL = PPP/R, substituting the right-hand sides of (7.9)–(7.12) for the respective indexes, applying (7.8) to eliminate ST_b and/or ST_d and (7.13) to eliminate WT (for the Walsh index), simplifying the resulting expression, and substituting P for PN/PT (via [7.5]) and PT for R (via [7.4]). The results are

$$\text{Laspeyres: } \mathrm{PL} = 1 + \mathrm{SN}_b(P - 1), \tag{7.18}$$

$$\text{Paasche: } \mathrm{PL} = \frac{P}{P(1 - \mathrm{SN}_d) + SN_d}, \tag{7.19}$$

$$\text{Fisher: PL} = \left[\frac{\text{SN}_b(P-1)+1}{\text{SN}_d(1/P-1)+1}\right]^{1/2}, \tag{7.20}$$

$$\text{Walsh: PL} = P^{\text{WN}}; \tag{7.21}$$

where PL and P are specific to the index under consideration.

The Laspeyres, Paasche, and Fisher PPP indexes possess the property of "characteristicity," that is, the price comparison between a given domestic country and the base country is determined solely by data in these two countries. Therefore, for these measures, moving to an N-country sample [$(N-1)$ domestic countries]—discussion of which is crucial for econometric analysis—does not affect the formula for PL in terms of P. For the Walsh index, "characteristicity" is not present. With $(N-1)$ domestic countries, WT and WN are redefined so that the arithmetic or geometric mean of tradable (or nontradable) shares runs over all N countries rather than only the base country and the domestic country. Therefore, the Walsh formula for PL retains its form with N countries; only WN is redefined.

As for the Geary-Khamis index, solving for the positive root of (7.17) and applying (7.4) yields:

Geary-Khamis:

$$\text{PL} = \frac{-D + \left(D^2 + 4 \cdot \text{ST}_b \cdot \text{ST}_d \cdot \text{SN}_b \cdot \text{SN}_d \cdot P \cdot Y\right)^{1/2}}{2 \cdot \text{ST}_d \cdot \text{SN}_d \cdot Y}, \tag{7.22}$$

where

$$\begin{aligned} D = {} & \text{ST}_b \cdot \text{ST}_d \cdot \text{SN}_b \cdot P + \text{ST}_b \cdot \text{SN}_b \cdot \text{SN}_d \\ & - \text{ST}_d \cdot \text{SN}_b \cdot \text{SN}_d \cdot Y \cdot P - \text{ST}_b \cdot \text{ST}_d \cdot \text{SN}_d \cdot Y. \end{aligned}$$

It is noted that P, SN_b and SN_d, and Y enter the formula for PL (with ST_b and ST_d eliminable via [7.8]). With N domestic countries (the variables for which may be subscripted by d), Eqs. (7.15) and (7.16) become

$$\text{PT}_I = \frac{\sum_d \text{YT}_d/\text{PPP}_d + \text{YT}_b}{\sum_d \text{YT}_d/\text{PT}_d + \text{YT}_b},$$

$$\mathrm{PN}_I = \frac{\sum_d \mathrm{YN}_d/\mathrm{PPP}_d + \mathrm{YN}_b}{\sum_d \mathrm{YN}_d/\mathrm{PN}_d + \mathrm{YN}_b};$$

and there are $(N - 1)$ equations of type (7.14) each specific to PPP_d, ST_d, SN_d, PT_d, and PN_d. Substituting for PT_I and PN_I leaves a system of $(N - 1)$ nonlinear equations determining the PPP_d, $d = 1, \ldots, N - 1$, the analytical solution of which is not attempted. Presumably, PL for a given domestic country (PL_d) depends on *all* the P_d, SN_d, and Υ_d, as well as on SN_b. The Geary-Khamis index exhibits extreme "noncharacteristicity."

Pleasingly, Eqs. (7.18)–(7.22) show that, for all the PPP indexes, $dPL/dP > 0$, justifying the use of the variables determining P as explanatory variables for PL.

Second issue: Assuming the law of one price for tradables, is PL a function of P alone so that it is legitimate to hypothesize that all (structural) variables determine PL by affecting P?

To answer this question, an N-country sample is assumed at the outset. For the Laspeyres, Paasche, and Fisher indexes, this sample serves merely to separate variables (PL, P, and SN_d) from parameters (SN_b), where a parameter is invariant over the $N - 1$ domestic countries. For the Walsh index, WN plays the role of SN_b, invariant over countries, and so may be regarded as a parameter. As Eqs. (7.18)–(7.21) show, then only for the Laspeyres and Walsh indexes is PL a function of the sole variable P. In the case of the Paasche and Fisher measures, PL depends on two variables, P and SN_d. Therefore SN_d, the share of nontradables in the domestic country's output, must enter a PL regression in its own right, that is, independent of whether it is a determinant of P.

For the Geary-Khamis index, Eq. (7.22) shows that for the two-country case, PL is a function not only of P but also of SN_d and Y. Extending the sample to N countries (meaning N observations) results in PL depending on the $3 \cdot (N - 1)$ variables, P_d, SN_d, and Υ_d, $d = 1, \ldots, N - 1$, a highly negative degrees-of-freedom situation.

Third issue: Given that conventional econometric work involves PL as the dependent variable and assuming that P can be expressed either as a linear or log-linear combination of its explanatory variables, is the conventional specification of a linear or log-linear functional form for PL (regressed on the determinants of P) correct?

With SN_b a parameter, a linear regression for the Laspeyres index is correct (that is, would provide proper tests of significance), as Eq. (7.18) shows. However, a log-linear formulation would be incorrect; for the logarithm of the right-hand side of (7.18) is nonlinearly related to log*P*. In contrast, a linear form for the Walsh index is illegitimate, with PL and *P* nonlinearly related [see Eq. (7.21)]. Yet a log-linear form would be correct; for $\log PL = WN \cdot \log P$, with WN a parameter.

However, the formulas for PL using the Paasche and Fisher indexes [Eqs. (7.19) and (7.20)] are inherently nonlinear in their right-hand-side variables, *P* and SN_d, so neither a linear nor a log-linear regression of PL on the determinants of *P* is consistent with the analytical relationship between PL and *P*. As for the Geary-Khamis index, the analytical expression for PL even in the two-country case [Eq. (7.22)] is too complex for consistency with a linear or log-linear formulation. For an *N*-country sample, the expression for PL resulting from solving the $(N - 1)$ equation system described previously would be even more inherently nonlinear (to say nothing of the degrees-of-freedom problem).[7]

Fourth issue: Should short-run variables be included in the determination of *P*?

The only such variable suggested in the literature is an international transfer, measured by a country's current-account imbalance; Salter (1959) and Clague (1986c) present models that clearly provide scope for a transfer to affect P. Alternative models, however, exhibit no such obvious impact of a transfer on P.[8] More fundamentally, a *cross-sectional* econometric determination of P (the sole interest in the literature) warrants stable, country-characteristic explanatory variables that are structural and long term in nature; and it is with reason that variables of this ilk dominate in empirical work.

Fifth issue: Granted that P may be presumed to depend only on long-run (or structural) variables, is it nevertheless legitimate to include short-run (or monetary) variables in an equation in which PL is the dependent variable?

Kravis and Lipsey (1983) and Clague (1986a, 1988a) take the view that short-run variables can enter simply as additional terms in a regression equation for PL that otherwise include long-run influences on PL operating through P. These authors use Dornbusch's (1976) overshooting model to justify inclusion of money-supply growth as an explanatory variable in the PL regression equation.[9]

However, propositions one and two of the accepted doctrine on the national price level negate the existence of short-run determinants of PL except insofar as they affect P. Equations (7.18)–(7.21) and an N-country version of (7.22) apply, and PL depends only on long-run variables: P (or those variables that determine P), SN_d, Υ, and the structural parameter SN_b.[10] There is no scope for short-run variables to influence PL except insofar as they affect P directly; and, for cross-sectional analysis, short-run explanatory variables for P are to be avoided (see *fourth issue* above).

Suppose, now, that the law of one price for tradables, proposition two, is abandoned (though a *tendency* toward this law must be assumed; else the distinction between tradables and nontradables, proposition one, is eliminated by default). Then the right-hand sides of Eqs. (7.18)–(7.22), and presumably the N-country analogue of (7.22), now include the multiplicative factor (PT/R); whereas previously this term was eliminated by Eq. (7.4). The additional variables that would enter the equation for PL must act to explain a nonunity PT/R, that is, nonfulfillment of the law of one price. Such factors as monopoly and oligopoly, transport and other transactions costs, trade restrictions, product differentiation, and differing commodity compositions of the price of tradables across countries—all of which are structural—act to explain the failure of the law of one price.[11] Again there is no scope for monetary variables except insofar as they affect P directly, independent of whether the law of one price holds.

Sixth issue: In the existing literature, long-run determinants of the national price level operate through P, that is, they are really theories about P. Therefore the question arises: Again assuming the law of one price for tradables, how can such hypothesis testing be more precise if PL, but not P, data are available?

Equations (7.18)–(7.21) re-solved for P yield

$$\text{Laspeyres: } P = \frac{\mathrm{PL}}{\mathrm{SN}_b} + \frac{\mathrm{SN}_b - 1}{\mathrm{SN}_b}; \tag{7.23}$$

$$\text{Paasche: } P = \frac{PL \cdot \mathrm{SN}_d}{\mathrm{PL}(\mathrm{SN}_d - 1) + 1}; \tag{7.24}$$

$$\text{Fisher: } P = \frac{E + \left(E^2 + 4 \cdot \mathrm{SN}_b \cdot \mathrm{SN}_d \cdot \mathrm{PL}^2\right)^{1/2}}{2 \cdot \mathrm{SN}_b} \tag{7.25}$$

where $E = \mathrm{PL}^2(1 - \mathrm{SN}_d) + \mathrm{SN}_b - 1$;

$$\text{Walsh: } P = \mathrm{PL}^{1/\mathrm{WN}}. \tag{7.26}$$

Equations (7.23)–(7.26) enable conversion of PL to P, which can then be used as the dependent variable in regressions. For the Geary-Khamis index, the relationship between PL_d for a given domestic country (d) and P_d, $d = 1, \ldots, N-1$, which would involve solving $(N - 1)$ nonlinear equations, is not known. There are two cases in which tests of significance are the same whether PL or P is the dependent variable: a linear equation with the Laspeyres index or a log-linear formulation with the Walsh index (see *third issue* above).

Seventh issue: Is it appropriate to adopt the Geary-Khamis index-number concept as the data basis for estimation and use of the national price level?

Geary-Khamis PPP and real-income data are exclusively employed in the most recent econometric studies of the national price level, whether of its estimation (Kravis and Lipsey 1983, 1987; Clague 1986a, 1988a) or of its use in facilitating short-cut estimates of real income (Clague 1986b). This is not surprising, as the ICP, having adopted Geary-Khamis as its official index-number concept in Phase 1 (Kravis et al. 1975), reached the point that by Phase 4 (United Nations 1986), even partial data on another index-number basis were not presented.

A disadvantage of Geary-Khamis is its mathematical complexity for $N > 2$. Kravis et al. (1982, 93) properly point out that sufficient resources overcome the *computational* complexity of Geary-Khamis. For *theoretical* purposes, however, analytical solutions are desirable, and these are extremely difficult to obtain for Geary-Khamis relative to the other indexes considered. For example, derivations of the PL-P analytical relationship and its inverse were not attempted above for $N > 2$.

Certainly, it is required that there be theoretical and empirical consistency of a researcher's selected index-number concept. In this light, Clague's adoption of Geary-Khamis data is inappropriate, because the PPP concept that he incorporates in the theory underlying his empirical work is the Walsh index.[12] A Walsh PPP index demands Walsh data. To make his use of Geary-Khamis data legitimate, Clague would have to use a Geary-Khamis PPP concept in his underlying theory, and the mathematics involved would be difficult indeed!

Empirically, the Geary-Khamis index (along with the Walsh index) has the advantage of being base-country invariant, but it lacks "characteristicity," even more than the Walsh index, to the point that a *negative* degrees-of-freedom situation must be overridden in econometric work. Other criticisms have been levied against the ICP Geary-Khamis data, including Isenman's (1980, pp. 65–66) admonition that basing decisions on these data would result in a misallocation of resources for less-developed countries. Kravis (1984, pp. 33–35; 1986, pp. 21–23) replies to the Isenman and related critiques, but does not address the weaknesses of Geary-Khamis suggested here. Most seriously, it is impossible for a methodologically correct econometric procedure to fit Geary-Khamis data (see *eighth issue* below). Primarily for this reason, the Fisher ideal index, and not Geary-Khamis, is used in the empirical part of this study.

Eighth issue: What is a methodologically correct econometric procedure for the estimation of PL?

Existing authors adopt an ad hoc approach to the econometrics of PL. Without rationale, they simply regress PL on the determinants of *P* and on monetary (short-run) variables. Not only do they ignore the PL-P analytical relationship and the other findings of *issues one to seven* but also they assert, without testing, a relative importance of the determinants of PL. In contrast, a correct econometric procedure consists of the following operations:

Step 1: Select the PPP-index concept.
Step 2: Obtain the PL-P analytical relationship for that PPP index.
Step 3: Regress PL on P and the other variables entering the PL-P analytical relationship. The resulting equation is an econometric approximation to that relationship.
Step 4: List, and provide theoretical justification for, the variables explaining *P*.
Step 5: Regress *P* on these variables. This provides not only a check on their appropriateness as explanatory variables for PL but also an input into econometric estimation of PL based on the PL-P analytical relationship (Step 8).
Step 6: List the variables other than those in Step 4, that are present in the PL-P analytical relationship. They warrant inclusion as PL explanatory variables in addition to those specified in Step 4 (or as reinforcing the effects of variables entering the PL regression on both grounds).
Step 7: Regress PL on the explanatory variables emanating from Steps 4 and 6. The explanatory power of the estimated equation in Step 3 indicates the error in the functional form (say, linear or log-linear)

of this (Step 7) procedure relative to the form of the PL-P analytical relationship.

Step 8: Insert the estimated observation vector for P resulting from the Step 5 regression, the true observation vector of SN_d (if indicated), and the parameters SN_b or WN (as indicated) into the PL-P analytical relationship (Step 2).

Step 9: Compare the predictive accuracy of the alternative estimates of PL provided by Steps 7 and 8.

Step 10: Use beta coefficients to delineate the relative importance of the explanatory variables for PL.

With an unknown PL-P analytical relationship for the Geary-Khamis index, Steps 2, 8, and 9 are impossible to perform. Furthermore, the complicated nonlinearity of the relationship makes Step 3 of dubious utility, even if the degrees-of-freedom problem is solved by confining explanatory variables to those pertaining to the domestic country of observation, the procedure (though without rationale) followed by those authors that use Geary-Khamis data. Fortunately, Fisher-ideal-index data were published along with Geary- Khamis in Phase 3 of the ICP. Ironically, while ignored by previous researchers in favor of the Geary-Khamis index, the Fisher data meet fully the econometric methodology and so are adopted here. A sample of 31 countries for the year 1975 is used, consisting of 30 domestic countries and the base country, the United States.[13] All regressions are fit in log-linear form.

7.1.4 Econometric Approximation of PL-P Analytical Relationship

Equation (7.20) indicates that the PL-P analytical relationship for the Fisher index may be approximated by a PL regression in which P and SN_d are explanatory variables, with a positive and a negative effect on PL, respectively. Equation El in Table 7.1 presents this log-linear approximation, with t-values in parentheses adjacent to the estimated elasticities. Three measures of goodness-of-fit are computed: R^2, the conventional R-squared based on the transformed (logarithmic) variables and corrected for degrees of freedom; r, the correlation coefficient between the true, nontransformed dependent variable, PL, and the antilog of the estimated (est) dependent variable, exp[est(logPL)]; and U, Theil's inequality coefficient of the N country-subscripted pairs, PL and exp[est(logPL)].[14]

Table 7.1 Regression equations

Equation	*E1*	*E2*	*E3*
Dependent variable	logPL	log*P*	logPL
Constant	−0.23 (6.53)	−2.49 (2.17)	−1.42 (2.46)
Price ratio (log*P*)	0.51 (40.89)		
Per capita income (logYC)		0.38 (2.86)	0.17 (2.57)
Share of services (logSSER)		0.16 (2.12)	0.07 (1.93)
Natural resources (logNARE)		−0.33 (2.68)	−0.20 (3.17)
Literacy (logLIT)		−0.45 (2.50)	−0.22 (2.46)
Share of nontradables (logSN)	−0.32 (6.38)	1.83 (4.81)	0.59 (3.12)
R^2	0.99	0.92	0.89
r	0.99	0.95	0.95
U	0.03	0.11	0.11
Degrees of freedom	28	25	25

Equation El (see Table 7.1) provides excellent justification for the use of Fisher data in regressing PL on the variables determining P and on SN. Both P and SN have highly significant coefficients (beyond the one percent level) with the correct sign, and the goodness-of-fit is impressive on all three criteria.

7.1.5 *Explanatory Variables for the Nontradable/Tradable Price-Level Ratio and the National Price Level*

Per Capita Real Income (YC): There are two separate rationales for per capita real income. First, it proxies the ratio of productivity in tradables to productivity in nontradables (higher in high-income countries), which has a positive effect on P and, through it, PL ("the productivity-differential model," discussed in Kravis and Lipsey 1983, pp. 11–14). Second, with nontradables labor-intensive relative to tradables and high-income countries labor-scarce, labor is relatively expensive in these countries and P high (the factor-proportions explanation, outlined in Bhagwati 1984).

Share of International Services (SSER): The ratio of balance-of-payments-services credits (excluding investment income) to GDP has both a demand and supply effect on P. Services provided to foreigners constitute a greater demand for "nontradables," resulting in a higher P. However, SSER can just as well measure the supply or abundance of "tradable services" (part of nontradables) as the demand, hence a higher

SSER implies a lower *P*. Therefore, the directional effect of *SSER* is indeterminate.[15]

Natural Resources (NARE): The share of the production of natural-resource industries (agriculture, hunting, forestry, fishing, mining, and quarrying) in GDP similarly has an uncertain directional effect on *P*. With tradables more natural-resource intensive than nontradables, a greater abundance of natural resources implies a higher *P*. However, if NARE is interpreted as representing demand for the country's natural-resource-intensive commodities, the effect on *P* is reversed.[16]

Literacy (LIT): With services (nontradables) skilled-labor intensive, a higher-quality labor force (a clear supply-side variable) implies a lower *P*. This variable is used in the literature.

Share of Nontradables (SN): The ICP definition of nontradable output is adopted: final expenditure on services plus construction. Kravis and Lipsey (1983, p. 15) state that, with a low elasticity of substitution between tradables and nontradables (an empirical result), a high share of nontradables in output (SN) implies a higher *P*. Clague (1986a, p. 321) rejects this argument, because SN itself is determined by the other influences on *P* (though he writes PL). Though Clague is correct that SN and *P* are jointly-determined variables, the issue is one of simultaneity, which awaits general-equilibrium modelling for its solution. Until that time, SN may enter the *P* equation in full realization that single-equation specification and estimation are convenient abstractions.

Certainly, SN must always be present in the equation for PL itself, because of the analytical expression for PL, Eq. (7.20). This equation shows that the *direct* effect of SN (SN_d) on PL is negative. With an indirect positive impact on PL (that operating through *P*), the net impact of SN on PL (coefficient of SN on PL) should be algebraically smaller than the indirect effect (indicated by the coefficient of SN on *P*).

7.1.6 Alternative Estimators of the National Price Level

Equation E2, exhibiting the regression of *P* on its determinants, has an exceptionally high R^2 for cross-sectional data, and all five explanatory variables are significant at the five percent level. Equation E3, for PL, is also satisfactory, with R^2 almost as high, four coefficients significant at the five percent level, and the remaining coefficient (that for SSER) nearly so. Further, all coefficients in these equations have a theoretically correct

sign. (The SSER and NARE coefficients have signs suggesting that these variables embody demand rather than supply.)

The PL-P analytical relationship for a given PPP index was honored in Sect. 7.1.4 in respect of inclusion of variables but not in respect of functional form, for a log-linear approximation was employed. Now the relationship can be given its full due as follows. Letting est(log$P$) be the estimated log$P$ observation vector from Equation E2, then exp[est(log$P$)] is plugged into Eq. (7.20) along with the true observation vector, SN, and the parameter SN_b (SN for the United States). The resulting estimate of PL may be compared with the true PL by means of their correlation coefficient (r) and inequality coefficient (U), shown in Equation E2.

An alternative, direct estimate of PL is exp[est(logPL)], where est(logPL) is the estimated observation vector on logPL obtained by applying Equation E3. This PL estimate, too, can be matched with the true PL via r and U. It turns out that these alternative estimates of PL, with identical goodness-of-fit statistics to two decimal places, are equally (and highly!) proficient at predicting the true PL.

7.1.7 Relative Importance of Determinants of the National Price Level

Previous authors have not investigated the relative importance of the determinants of the national price level. Rather, they *assume*, explicitly or implicitly, that real per-capita income is the most important explanatory variable.[17]

Beta coefficients provide an objective, if somewhat arbitrary, econometric answer to the question of relative contribution of individual variables to the explanation of the dependent variable. Because the estimated coefficients are elasticities rather than slopes, the beta coefficients are computed as the product of the estimated coefficient and the ratio of the coefficient of variation (ratio of standard deviation to mean) of the nontransformed (level rather than logarithmic) regressor under consideration to the coefficient of variation of the nontransformed dependent variable (PL).

Beta coefficients so computed are, in order of absolute value, natural resources (−0.35), share of nontradables (0.32), per capita income (0.32), literacy (−0.18), and share of services (0.11). The accepted view of per-capita income as the predominant explanatory variable receives no

support. Natural resources and the share of nontradables are at least as important.

7.1.8 Principal Conclusions

a. There is an analytical relationship between the national price level, PL, and the nontradable/tradable price-level ratio, *P*, that varies with the PPP index adopted and that theoreticians and econometricians ignore at their peril.
b. Precise hypothesis testing for those determinants of PL that operate through *P* requires estimation of an equation in which *P* rather than PL is the dependent variable.
c. Not all long-run or structural influences on PL operate (or operate exclusively) through *P*; some instead (or also) affect PL directly.
d. Dropping the assumption of the law of one price for tradables alters the PL-P analytical relationship but does not in itself justify inclusion of short-run or monetary variables in the explanation of the national price level.
e. Conventional functional forms of the estimating equation for PL violate the PL-P analytical relationship and can lead to incorrect hypothesis testing. The amount of approximation involved in these functional forms is empirically testable.
f. There are two methods for estimating PL. Traditionally, PL is regressed directly on its explanatory variables. Alternatively, the regression for *P* is incorporated into the PL-P analytical relationship.
g. The conventional wisdom that per capita real income is the most important variable in the explanation of PL receives no support.
h. There exist theoretical and econometric problems in the use of the Geary-Khamis index to develop theories and test hypotheses concerning PL and *P*.

Appendix: The Data

All variables refer to the calendar year 1975; except for India and Iran, for which most data are for the year beginning April 1 or March 21, respectively.

National Price Level: PL = PPP/*R1*, where PPP is the "augmented" Fisher-ideal-index PPP for GDP and *R1* is the annual-average exchange rate, both measured as the number of units of domestic currency per dollar (Kravis et al. 1982, pp. 10, 253–85). The source also provides a list of the 31 countries in the sample.

Share of Nontradables: SN (Kravis et al. 1982, p. 194).

Nontradable/Tradable Price-Level Ratio: *P* is computed from Eq. (7.25) with SN_d = SN, and SN_b = SN for United States.

Per Capita Real Income: YC = (YD/PPP)/POP, where YD is GDP at national prices, millions of domestic-currency units, and POP is mid-year population, millions of persons (Kraviset al. 1982, pp. 10, 12).

Share of Services: SSER = *(R2* · SER)/YD, where *R2* is the annual-average exchange rate, number of units of domestic currency per Special Drawing Right (SDR), and SER is total service credits (excluding investment income) in the balance of payments, in SDRs (International Monetary Fund [1980] for Iran; International Monetary Fund [1983] for other countries). Unlike the other flow data, *SER* is on a calendar-year basis for India and Iran. For Belgium and Luxembourg, figures are consolidated and currencies are interchangeable; therefore, in the SSER formula, YD is the sum of the figures for the two countries and the resultant value of SSER is applied to both countries.

Natural Resources: NARE = (AGR + MIN)/YFC, where AGR is GDP originating in agriculture, hunting, forestry, and fishing; MIN is GDP originating in mining and quarrying; and YFC is GDP at factor cost, all in millions of domestic-currency units (OECD [no date] for all OECD countries except the Netherlands; United Nations [1985] for all other countries except Malaysia). For Italy, a joint figure for GDP originating in mining (and quarrying) and manufacturing is allocated in proportion to 1973 values, found in United Nations (1980); for Luxembourg, it is allocated in proportion to 1975 values, found in United Nations (1982). For Malaysia, the UN figures are available for 1973 but not 1975. Estimates for 1975 are obtained from data for that year in World Bank (1983), made consistent with UN data by multiplication by the ratio of the UN to World Bank figure for 1973, for each series.

Literacy Rate: LIT (World Bank 1983). For countries for which a figure for 1975 does not exist, an estimate is obtained by linear interpolation of figures for the years closest to 1975 on either side, except for Austria for which the 1974 figure is taken.

Notes

1. As Clague (1988a, p. 238) writes: "It is obvious, moreover, that the tradability of goods is a matter of degree rather than a simple dichotomy, but theorists need to make simplifications, and the assumption of a tradable/nontradable dichotomy has proven quite useful in thinking about national price levels."
2. Clague (1985, p. 998) notes: "It is typically assumed that the law of one price holds for tradables but not for nontradables." Other statements to this effect are made by Clague (1986a, p. 321; 1988a, pp. 237–238); Kravis and Lipsey (1983, p. 11); and Kravis et al. (1978, pp. 218–219).
3. The third proposition is noted by Clague: "The key to the change in *RPL* [the national price level] is found by looking at the relative prices of services and commodities" (1986a, p. 321) and "the relationship of the prices of nontradables to the prices of tradables is at the heart of most available theories of national price levels" (1988a, p. 238). Other statements of this methodology are made by Kravis and Lipsey (1983, pp. 11, 17) and Kravis (1984, p. 29).
4. When a regression is run on *P*, which is rare, it is done only as subsidiary to the principal estimation, as in Kravis and Lipsey (1983, pp. 24–25). Sometimes regressions are run *separately* on the components of *P: PN* (the nontradable price-level ratio) and *PT* (the tradable price-level ratio), as is done by Kravis and Lipsey (1983, pp. 23–24; 1987, pp. 112–114) and Clague (1986a, p. 323). Such bifurcation of *P* makes no sense.
5. While the definitions are unusual, they are consistent with conventional formulations, as for example, in Ruggles (1967, pp. 181–184) and Kravis et al. (1978, pp. 73–76; 1982, pp. 74–77, 89–90).
6. See Kravis et al. (1978, p. 74). In other words, one unit of base-country currency has the same purchasing power as one unit of international currency. This is true only at the GDP level; the base-country/international PPP at any disaggregate level (say, tradables or nontradables) is *not* identically equal to unity, as noted in Kravis et al. (1982, p. 7).
7. Although a linear (log-linear) formulation with a Laspeyres (Walsh) PPP index would be correct, it happens that every econometric study to date has erred in specification of the functional form. For example, Kravis and Lipsey (1983, 1987) and Clague (1986a, 1988a) use linear or log-linear functional forms with the Geary-Khamis index. Salazar-Carrillo (1982b) adopts the Walsh index (see Salazar-Carrillo 1982a), but he uses a linear rather than log-linear functional form!
8. Clague's (1986c) result holds under specific, but not purely mobile, factors of production. Kravis and Lipsey (1983, p. 16) argue, first, that generally accepted theory offers no support for any unambiguous effect

of a transfer on PL and, second, that true causation is actually the reverse (from PL to the current-account balance.)

9. As Clague (1988a, p. 247) states: "The exchange rate responds more quickly to changes in the money supply than the prices of goods; consequently, a rapid expansion in the money supply should be associated with a lower-than-normal price level."
10. Of course, for the Geary-Khamis index, $(N - 1)$ of each of the variables P_d, SN_d, and Y_d, indexed by d, would be involved.
11. These influences are in accordance with the literature on the law of one price, as summarized in Officer (1986, pp. 161–163).
12. See Clague (1985, p. 1002; 1986a, p. 320; 1986c, p. 160; 1988a, p. 238).
13. Following Clague (1986a, b), the ICP 34-country sample is reduced to 31 by excluding observations on three centrally-planned economies (Hungary, Poland, and Romania) because of unavailability of data on explanatory variables.
14. The definition of U^2 is $\Sigma(E - A)^2/\Sigma A^2$, where A is the actual and E the estimated value of the variable under consideration. Theil (1971, pp. 26–52) is concerned with time-series forecasting errors. Therefore he defines A and E as percentage changes from the previous period's actual value. With cross-sectional data, this is not possible; so A and E are taken as level, nontransformed variables. A zero value for U corresponds to a perfect fit between E and A.
15. Clague (1985, p. 1005; 1986a; 1988a, pp. 240–241) considers only tourism rather than all services and interprets the variable as having an unambiguously demand effect.
16. Clague (1986a, 1988a) uses alternative variables, each of which covers only part of the natural-resources sector: agricultural land per capita (unambiguously a supply variable) and the share of mineral production in GDP.
17. Explicitly, Kravis and Lipsey (1983, p. 29) state, without empirical testing: "Real income per capita is the major source of variation among countries in the price levels of both tradable and nontradable goods and in the total price level." Implicitly, Clague (1988a, p. 239) writes: "Regression equations explaining national price levels practically always include real per capita income as one of the independent variables. Theoretical attention has therefore turned toward variables that would explain price levels when per capita income is held constant."

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