Purchasing Power Parity from Ancient Times to World War II

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Summary

"Our willingness to pay a certain price for foreign money must ultimately and essentially be due to the fact that this money possesses a purchasing power as against commodities and services in that foreign country."—Cassel (1922, p. 138)

The purchasing power parity theory is based on the common-sense idea that money is valued for what it can buy. If a basket of commodities costs $2000 in the United States, and the same basket costs £1000 in the United Kingdom, then the purchasing power parity (PPP) between the two currencies is $2 = £1, or $2 per U.K. pound. This exchange rate is called "absolute" purchasing power parity; it pertains to a point in time. The absolute PPP *theory* states that the equilibrium exchange rate is indeed absolute PPP, and that the actual exchange rate is the equilibrium rate (although this might take time to achieve, so PPP might hold only in the "long run," as economists like to say).

A second version of PPP theory considers movements of prices and the exchange rate over time. Consider the exchange rate in a "base period," meaning a past year in which the exchange rate is assumed to be at its equilibrium value. Relative PPP is defined as U.S. inflation divided by U.K. inflation, all multiplied by the base-year exchange rate. For example, suppose that the base-year exchange rate is $3 = £1, and that U.S. prices have doubled and U.K. prices tripled since the base period. Then "relative PPP" is 2/3 the base-period exchange rate, that is, $2 = £1. Relative-PPP theory asserts that the current *actual* exchange rate, or at least the current *equilibrium* exchange rate, is relative PPP as defined.

Obviously, relative PPP is not as strict as absolute PPP. Also, PPP theory in general allows for approximations, errors, and other variables to help determine the exchange rate.

This article interprets and exposits PPP theory in broad form, and presents how this theory applies to historical experiences. The table of contents and list of tables provide a guide, so the reader can obtain such detail of PPP exposition as desired, and can also quickly find a particular historical episode of interest. Section I is a systematic, rather technical, presentation of PPP theory, including criticisms of the theory. Section II applies the theory to early times, going back to Ancient Rome, for which data to compute PPP are lacking but nevertheless an assessment of the role of PPP can be made.

Section III provides background, of necessity partly technical, for section IV. That section surveys all tests of PPP that use a specific historical experience as a "testing laboratory." An attempt at a comprehensive survey is made; but some studies may have

been omitted, for which this reviewer apologizes. For a quick assessment of the applicability of PPP to a given experience, the reader is invited to consider the final column of the tables in section IV. That column provides a judgment as to whether a particular scholarly study (given by the row in the table) finds that the PPP theory is fulfilled ("positive" result), not fulfilled ("negative" result), or partly fulfilled ("mixed" result).

Section V looks at actual situations in which PPP theory was applied to determine a new exchange rate, but only in the historical experience, taken to end in the year 1939 (which also applies to section IV). Finally, section VI offers a few concluding comments. The list of references follows.

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I. Purchasing-Power-Parity Theory

"There is something to the idea of PPP; the question is what."—Houthakker (1978, p. 71)

1. equilibrium versus causal relationship

Purchasing power parity (PPP) theory is concerned with the relationship between (i) domestic and foreign combinations of commodity prices, and (ii) the exchange rate. The word "combinations" (or groups, weighted averages, levels, indexes, etc.) is used advisedly. The price concept is general rather than commodity-specific.

Traditional PPP literature—beginning with scholars of the School of Salamanca in 16th-century Spain, continuing through the writing of Gustav Cassel (the greatest proponent of PPP) and incorporating the work of those modern economists faithful to Cassel—see PPP theory as involving a causal relationship, and one that is unidirectional: combinations of prices (at home and abroad) determine the exchange rate. As Yeager (1976, p. 210) asks rhetorically: "How do price levels govern exchange rates? Is an opposite influence—from exchange rates to prices—of any real importance?" Dornbusch 1987, p. 1075) states quite explicitly:

> Purchasing Power Parity (PPP) is a theory of exchange rate determination. It asserts (in the most common form) that the exchange rate change between two currencies over any period of time is *determined* by the change in the two countries' relative price levels….the theory singles out price level changes as the *overriding determinant* of exchange rate movements. [italics added]

Cassel (but not always later writers) was careful to point out that the exchange rate determined by price levels was the equilibrium, not necessarily the actual, exchange rate. Then, as Cassel asserts, there is a tendency for the actual exchange rate to equal the equilibrium exchange rate. Modern writers use the term "long-run" to characterize the PPP-determined rate.

The causal characteristic of traditional PPP theory is omitted, or even negated, in much modern literature. Instead, PPP is treated as purely an equilibrium (or long-run) relationship between price levels and the exchange rate. The typical view is described accurately by Isard (1995, p. 59):

> the PPP hypothesis *does not make any general assertion about the direction of causation* between exchange rates and national price levels. It is quite consistent with a process of two-way causation, with exchange rates adjusting to changes in the ratios of national price levels while inflation rates are simultaneously responsive to changes in exchange rates….the PPP hypothesis is a theory about the relationship between endogenous variables. [italics added]

2. absolute versus relative PPP: the PPP variable

This section presents PPP as a variable; PPP as a theory is discussed in the next section. Of course, the most important ingredient in PPP theory is the PPP variable. Here absolute and relative PPP are distinguished. Consider first absolute PPP. A country's price *level* is a weighted average of absolute (money) prices of commodities. The purchasing power of this currency, the currency's command over goods and services, is the inverse of the price level. Note that the *dimension* of purchasing power is the number of "physical units of commodity" per unit of currency. Now, the absolute PPP between two countries' currencies is the ratio of the countries' purchasing powers. Define the purchasing-power parity of the domestic currency with respect to the foreign currency as the foreign/domestic relative purchasing power, that is, the ratio of the domestic to the foreign price level. Let

pl^d_t = domestic price level in period t

pl^f_t = foreign price level in period t

$P^a_t = pl^d_t / pl^f_t$ = absolute PPP in period t

The dimension of P^a_t is number of units of domestic currency per unit of foreign currency (under the assumption that the "physical unit of commodity" is the same in the two countries). It should be noted that P^a_t is a variable that pertains to a point in time (or one time period), the current period, t. All variables defined in this section can be time series, so that t = 1…n; or they can be constructed only for discrete periods, for example, t = m, n or even t = n alone. *In practice, absolute PPP is calculated only as a domestic/foreign index number*; so pl^d_t and pl^f_t are not computed separately.

In contrast, relative PPP involves price *movements*. Its components are price *indexes* rather than price levels, and each country's price index may have its own specific weighting pattern. Let

p^d_t = domestic price index in period t

p^f_t = foreign price index in period t

E_t = exchange rate, number of units of domestic currency per unit of foreign currency, in period t

0 = base period

It is convenient to use multiplicative factors to adjust p^d_t and p^f_t so that they have a common time base ("the base period"): $p^d_0 = p^f_0 = 100$ or perhaps 1. E_t is the observed or recorded exchange rate, termed the "nominal" exchange rate. Because it has dimension, E_t is not comparable to the price indexes. However, E_t/E_0, the exchange rate in period t relative to period 0, is expressed compatible with p^d_t and p^f_t based on $p^d_0 = p^f_0 = 1$. Consider now two concepts of relative PPP:

$P^{r1}_t = p^d_t/p^f_t$ = dimensionless relative PPP in period t

$P^{r2}_t = (p^d_t/p^f_t)\cdot E_0 = P^{r1}_t\cdot E_0$ = exchange-rate-compatible PPP in period t

P^{r1}_t is dimensionless, because both p^d_t and p^f_t are pure numbers, and $P^{r1}_0 = 1$. P^{r2}_t has the dimension of E_t: number of units of domestic currency per unit of foreign currency, and $P^{r2}_0 = E_0$. Because E_0 is a constant (for a given base period), the variation in P^{r2}_t is completely captured by that of P^{r1}_t.

The terms "PPP," "absolute PPP," and "relative PPP" can designate either PPP as defined above or the corresponding PPP theory. The meaning is clear from the context.

3. types of PPP theories

PPP theory is typically described by statements such as "the exchange rate equals (and/or is determined by) the price level at home relative to the price level abroad." A full understanding of PPP requires statements with greater precision and that are derived from broader forms of the theory. This is achieved here by moving from the most-general PPP theory to the most-restrictive.

All PPP theories can be represented by the general implicit function G(E, P, X) = 0. For the absolute PPP theory: E is E_t, and P is P^a_t. For the relative PPP theory: E is either E_t or E_t/E_0; P can be P^{r1}_t, P^{r2}_t, or the vector (p^d_t, p^f_t). For both PPP theories, X is a vector of variables that can include (i) E and/or P in periods previous to t, and (ii) additional variables in period t and/or earlier periods.

The E_t that results from solving the G function can be interpreted either as the *actual* exchange rate in period t, the *equilibrium* exchange rate in period t, or the *long-run* *equilibrium* exchange rate given the information available in period t. As is customary in economic theory, and for simplicity here, there are no error terms. In particular, all variables are assumed to be non-stochastic (there are no "errors in variable"), and the functional equation G is assumed to be exact (there are no "errors in equation"). Where empirical work is discussed, both these assumptions will be removed.

For a specific G function to be considered a PPP theory, it is necessary that certain minimum requirements be satisfied. *First*, the G equation must be solvable in terms of E: $E = g(P, X)$. *Second*, partial derivatives must have sign consistent with PPP theory: $\partial E/\partial P > 0$, $\partial E/\partial p^d_t > 0$, $\partial E/\partial p^f_t < 0$.

The variables (E, P) may enter in several ways. PPP theory is trivariable if (E, P) is (E_t, p^d_t, p^f_t) or $(E_t/E_0, p^d_t, p^f_t)$. Thus a trivariable theory involves the exchange rate, domestic price index, and foreign price index entering as separate variables. Only the relative PPP theory can be trivariable (see section 2 above).

PPP theory is bivariable if (E, P) is (E_t, P^a_t), (E_t, P^{r1}_t), or (E_t, P^{r2}_t). These specifications combine the domestic and foreign price into a ratio variable, and can involve either absolute or relative PPP. The relative PPP theory is also bivariable if (E, P) is $(E_t \cdot p^f_t, p^d_t)$ or $(p^d_t/E_t, p^f_t,)$. Thus combining a price index with the exchange rate to form a single variable is applicable only to relative PPP.

Define the "real" exchange rate (R) as the price-adjusted nominal exchange rate. There are three concepts of the real rate, corresponding to the three concepts of PPP:

$R^a_t = E_t/P^a_t = E_t \cdot (pl^f_t/ pl^d_t)$

$R^{r1}_t = E_t/P^{r1}t = E_t \cdot (p^f_t/p^d_t)$

$R^{r2}_t = E_t/P^{r2}_t = (E_t/E_0) \cdot (p^f_t/p^d_t)$

Then PPP theory is univariable for $(E, P) = R^a_t$, R^{r1}_t, or R^{r2}_t. A univariable theory has the nominal exchange rate, domestic price, and foreign price combined into one variable, the real exchange rate. Note that R^{r2}_t is dimensionless, and therefore, in principle, is the preferred definition of the relative-PPP real exchange rate. However, authors often construct the relative-PPP real exchange rate as R^{r1}_t, analogous to (and sometimes even considered as) R^a_t, the absolute-PPP real exchange rate. The dimension becomes that of E_t: number of units of domestic currency per unit of foreign currency. Given the base period, E_0 is a constant for all t. Therefore omission of E_0 (that is, using R^{r1}_t instead of R^{r2}_t), does not affect the variation of the real exchange rate.

For the specific G functions in the theoretical and empirical PPP literature (but not for all conceivable G functions satisfying the two minimum requirements mentioned above), univariable and bivariable theories have the property of "symmetry" (identical magnitude effects of the domestic and foreign price levels on the exchange rate: $(\partial E/\partial p^d/\partial E/\partial p^f = -1)$ and univariable theory possesses the property of "proportionality" ($\partial E/\partial P = k$, where k is a constant; or, equivalently, $\partial \log E/\partial \log P = 1$). G functions linear or log-linear in E, P, and X yield these properties. However, only a log-linear G function has symmetry as well as proportionality.

Univariable, bivariable, and trivariable theories may or may not have the property of "exclusiveness" (the term coined by Edison, 1987, p. 378). The G function involves exclusivity (perhaps a better term) if the X vector does not include any variables other than lagged E and/or lagged P. What we term here "super-exclusivity" involves the absence of even the latter variables; the G function reduces to G(E, P) = 0.

If PPP theory is univariable and super-exclusive, the G function becomes G(R) = 0, where R denotes R^a_t, R^{r1}_t, or R^{r2}_t. If the G function is linear, it reduces to R = c, where c is a constant. Letting c be unity yields the strictest form of PPP theory, absolute PPP with a unitary real exchange rate: $R^a_t = E_t \cdot (pl^f_t / pl^d_t) = 1$, so

$$E_t = P^a_t = pl^d_t / pl^f_t \qquad (1)$$

There is zero deviation of the exchange rate from PPP. This is "strict absolute-PPP theory" ("strict absolute PPP," for short). The nominal exchange rate equals absolute PPP, the ratio of the domestic to the foreign price level. Taking logarithms,

$$\log E_t = \log pl^d_t - \log pl^f_t \qquad (2)$$

No *changes* in variables are pertinent, as absolute PPP pertains to a point in time (or single time period).

For relative PPP, consider first R^{r2}_t. Applying the same conditions that yield equation (1), $R^{r2}_t = (E_t/E_0) \cdot (p^f_t/p^d_t) = 1$. So

$$E_t/E_0 = p^d_t/p^f_t \qquad (3)$$

Equation (3) represents "strict relative PPP"; there is again no deviation from (now relative) PPP. Recall that E_t/E_0 has the interpretation as the index of the exchange rate in the current period relative to the base period. So equation (3) states that the exchange-rate index is the ratio of the domestic price index to the foreign price index. Dividing equation (3) by its lagged-one-period equivalent,

$$E_t/E_{t-1} = (p^d_t/p^d_{t-1})/(p^f_t/p^f_{t-1}) \qquad (4)$$

Suppose that one begins rather with $R^{r1}_t = E_t \cdot (p^f_t/p^d_t) = 1$, whence $E_t = p^d_t/p^f_t$. The latter equations, though used in empirical work, make no economic sense, because the dimensions of the left-hand and right-hand sides differ. However, and fortunately, dividing the equation $E_t = p^d_t/p^f_t$ by its lagged-one-period equivalent again yields equation (4). So, from a time-series standpoint, it makes no difference whether one equates R^{r1}_t or R^{r2}_t to unity.

By definition, $\Delta E_t = E_t - E_{t-1}$, $\Delta p^d_t = p^d_t - p^d_{t-1}$, $\Delta p^f_t = p^f_t - p^f_{t-1}$. Then equation (4) becomes

$$(1 + \Delta E_t/E_{t-1}) = (1 + \Delta p^d_t/p^d_{t-1})/(1 + \Delta p^f_t/p^f_{t-1}) \qquad (5)$$

which, omitting the term $(\Delta p^f_t/p^f_{t-1})\cdot(\Delta E_t/E_{t-1})$ as inconsequential for small changes, reduces to

$$\Delta E_t/E_{t-1} = \Delta p^d_t/p^d_{t-1} - \Delta p^f_t/p^f_{t-1} \quad (6)$$

Multiplying each term in equation (6) by 100, the percentage change in the exchange rate equals the percentage change in the domestic price level minus the percentage change in the foreign price level, that is, domestic inflation minus foreign inflation.

Suppose that, rather than zero deviation, there is a period-specific percentage deviation from PPP, k_t, in any period t. Then equation (4) is replaced by

$$E_t/E_{t-1} = (k_t/k_{t-1})\cdot(p^d_t/p^d_{t-1})/(p^f_t/p^f_{t-1}) \quad (7)$$

which, if $k_t = k_{t-1}$, reduces to equation (4). Thus strict relative PPP holds not only for zero deviation from PPP but also for a constant percentage deviation.

Taking logarithms in equation (4), and noting that $\log(E_t/E_{t-1}) = \log E_t - \log E_{t-1} = \Delta\log E_t$ (and similarly for p^d_t, p^f_t),

$$\Delta\log E_t = \Delta\log p^d_t - \Delta\log p^f_t \quad (8)$$

In the 1980s, authors from Frenkel (1981, pp. 146-147) to MacDonald (1988, p. 216), while acknowledging that equation (8) is strict relative-PPP theory, asserted in effect that an equation analogous to (2):

$$\log E_t = \log p^d_t - \log p^f_t \quad (9)$$

represents strict absolute PPP. That is obviously incorrect; for absolute PPP involves price levels rather than indexes. The error was recognized by several authors, including Crownover (1997, pp. 34-36) and Moosa and Bhatti (1997, p. 209). However, these authors go on to say that equation (9) is rather another expression of strict relative PPP, in addition to equation (8). That is incorrect; for taking logarithms of both sides of equation (3) produces not equation (9) but rather

$$\log E_t = \log p^d_t - \log p^f_t - \log E_0 \quad (10)$$

A specific constant term, $\log E_0$, must be included in equation (9). This point has been missed in the literature. It is untrue, as these authors in effect state, that PPP theory in the form of equation (9) involves a zero constant.

4. mechanisms underlying strict PPP theory

The mechanisms underlying strict absolute PPP are perfect commodity arbitrage and strong similarity of the domestic and foreign economies. International arbitrage that is costless, instantaneous, and based on full information, results in the "law of one price" (LOP) for each commodity that is traded. Let p^d_{it} (p^f_{it}) denote the price of commodity i in the domestic (foreign) country in period t. Then the LOP is $p^d_{it} = E_t \cdot p^f_{it}$ for all traded commodities i.

If (1) all commodities produced in either or both countries are traded, (2) the weighting patterns of the countries' price levels are identical, and (3) there is perfect international commodity arbitrage, then the result is the LOP at the aggregate level, that is, strict absolute PPP. Suppose, however, that not all commodities are traded. Then strict absolute PPP requires either (4) perfect substitutability of nontraded and traded commodities, or (5) strong similarity of the economies, in the sense that the conditions necessary for factor-price equalization are satisfied. Some of these conditions are: perfect competition in all markets, unitary homogeneous production functions for all commodities, identical production functions in the two countries for any given commodity, and similarity of tastes in the two countries.

The traditional justification of strict relative PPP involves only monetary factors, and not real factors, influencing commodity prices and the exchange rate. Real shocks either do not occur or cancel themselves out. There is pure inflation or deflation, with no change in relative prices, in both the domestic and foreign economies. Also, with an effective absence of money illusion, there is neutrality of money. There is no need for the LOP. In fact, none of conditions (1)-(5) are necessary. In particular, the weighting patterns of the countries' price indexes need not be the same. It may be noted that strict relative PPP holding could perpetuate a deviation from strict absolute PPP.

An alternative mechanism for relative PPP involves asset, rather than commodity, arbitrage. Let

i^d_t = domestic nominal interest rate in period t

i^f_t = foreign nominal interest rate in period t

r^d_t = domestic real exchange rate in period t

r^f_t = foreign real exchange rate in period t

$\Delta p^d_t/p^d_t$ = proportionate change in domestic price index in period t

$\Delta p^f_t/p^f_t$ = proportionate change in foreign price index in period t

$\Delta E_t/E_t$ = proportionate change in exchange rate in period t.

Of these variables, only the nominal interest rates are known at the beginning of period t. All other variables are known only at the end of the period. The denominators in the proportionate-change variables are defined in terms of timing, to make that statement true.

By definition, $i^d_t = r^d_t + \Delta p^d_t/p^d_t$ and $i^f_t = r^f_t + \Delta p^f_t/p^f_t$. With perfect international arbitrage in financial assets, there is both uncovered interest parity ($\Delta E_t/E_t = i^d_t - i^f_t$) and the "law of one real interest rate" up to a known constant (r^d_t - r^f_t = k). From these relationships, it follows that:

$$\Delta E_t/E_t = \Delta p^d_t/p^d_t - \Delta p^f_t/p^f_t + k \qquad (11)$$

Except for k, none of the terms in equation (11) is known at the beginning of period t. So, taking the expected value, EV, of each term,

$$EV(\Delta E_t/E_t) = EV(\Delta p^d_t/p^d_t) - EV(\Delta p^f_t/p^f_t) + k \qquad (12)$$

One can implicitly multiply each term in equation (12) by 100. Then equation (12) states that the expected percentage change in the exchange rate (appreciation of the foreign currency) is the difference between expected domestic inflation and expected foreign inflation, allowing for a constant. The similarity to equation (6), strict relative PPP, is striking, but there are differences. First, there is the existence of a constant term in equation (12). If the strict "law of one real interest rate" ($r^d_t = r^f_t$) is applied, then the constant term vanishes. Second, equation (12) is PPP in expectation form, and therefore has been termed "ex ante PPP." (Because its underlying propositions involve efficient financial markets, equation (12) is also called "efficient-markets PPP.") If one assumes perfect-forecast expectations (that is, rational expectations without forecasting error), then equation (12) becomes equation (6), except for the constant term. Third, and related, the denominators of the variables in equation (6) are known, unlike those in equation (12).

5. criticisms of PPP

It is pedagogically useful to consider criticisms of PPP theories in their strict form. Limitations of strict absolute PPP fall into two categories. First, there are elements that reduce the accuracy of PPP but leave the tendency to PPP unaltered. If one were to include an error term in the strict absolute-PPP G function, one would say that these elements give rise to a variance of the predictive error of PPP, but the mean error of zero (predicted by strict PPP) remains. These elements themselves are in two subcategories. The first subcategory consists of factors that adversely affect the working of the LOP. These factors include transactions costs, trade restrictions, transport costs, imperfect competition, and product differentiation. Their existence means that the LOP may not hold exactly, but the tendency to the LOP fulfilled remains.

The second subcategory comprises factors other than those directly impacting on the LOP. One such factor consists of non-price variables that affect the demand for and supply of traded goods, and thence the exchange rate. The most important such factor is income. However, as Yeager (1976, p. 215) argues, prices and income are generally correlated over the business cycle. Yeager could have said further that PPP as a long-run proposition is unaffected by cyclical variations in income. Another influence on the exchange rate consists of the non-commodity components of the balance of payments, in particular, the investment and financial accounts. In response, at least in the long run, the effect of financial flows on the balance of payments could be offset by the cumulative associated reflow of investment payments. As Yeager again notes, any deviation from

PPP caused by capital flows (or indeed any non-price force, such as income) would give rise to price-determined trade flows (commodity arbitrage) to reduce the divergence. So PPP remains an unbiased theory.

The second category consists of forces that give rise to a systematic divergence from PPP, that make PPP a biased theory. *The mere existence of nontraded goods is not among these forces, and does not in itself generate a biased PPP theory.* The reason is that the prices of tradables and nontradables are closely related through many mechanisms: tradables or nontradables can be produced with common factors, each can be an input in the other's production, there can be a high degree of substitution in production and consumption between tradables and nontradables, etc.

Rather, *the forces that bias PPP are international differences in technology, factor endowments, and tastes*. In effect, these involve divergences from factor-price equalization—and affect PPP theory in a biased way. For example, higher-per-capita-income countries have generally higher productivity, associated with a higher tradables/nontradables productivity ratio, resulting in a higher ratio of the price of nontradables to price of tradables (Balassa-Samuelson hypothesis). Then, with the LOP holding for the price of tradables, absolute PPP yields an exchange value of the higher-income-country's currency that is biased downward compared to the true equilibrium value. This is a systematic bias, monotonically increasing with the per-capita income difference, or the level of development, between the higher-income and lower-income country.

Turning to strict relative-PPP theory, its great advantage is that is unaffected by the limitations—even the biases—of absolute PPP, providing that these factors are invariant since the base period. Of course, if these factors change over time in a non-proportionate way, then relative PPP is subject to similar limitations.

A disadvantage of relative PPP is the required selection of a base period. If the base period does not involve equilibrium, then relative PPP continues the disequilibrium. This is a bias situation.

Relative PPP is upset by real changes occurring in economies, whether these changes are autonomous shocks or are consequences of monetary disturbances. In particular, in the short run, money is non-neutral, if only because of labor (and other resource) contracts. However, providing monetary changes dominate the real changes, relative PPP still applies in an unbiased, albeit approximate (non-strict), form.

In the short run, the greater price rigidity in commodity markets compared to the foreign-exchange market, means a quicker adjustment of the foreign-exchange market to "news" and a consequent "temporary" divergence from relative PPP.

Regarding ex-ante PPP, each of its underlying propositions is subject to criticism. Uncovered interest parity (UIP) may not hold exactly, due to transactions costs. More important, the existence of an exchange-rate-risk premium yields a divergence from UIP that is non-proportional, because this risk premium can be time-varying. The law of one real interest rate (even up to a constant) lacks the foundation of a risk-free, real-interest-paying asset in each country, with arbitrageurs heavily transacting between these assets.

Hallwood and MacDonald (2000, pp. 126-127) make a fundamental criticism of efficient-markets PPP. The theory deals with the financial account of the balance of payments, but does not require that this account be in ultimate balance. Financing of a financial-account deficit (or surplus) by a current-account surplus (or deficit) cannot occur indefinitely. In a sufficiently long run, each of these accounts will be in balance.

PPP as a causal relationship sees the exchange rate as the determined variable and commodity prices as causal variables; but it cannot be denied that there are also chains of causation running from the exchange rate to prices. Yet, as Yeager (1976, pp. 223-226) discusses, even under mutual causation, “causal PPP” holds in an approximate sense, providing that causation is stronger from price levels to the exchange rate than in the opposite direction. This causation pattern is likely for a floating exchange rate, providing there is responsible monetary policy.

PPP as a causal theory is weakened under a fixed (“pegged”) exchange rate. In this situation, it would appear that prices must be the adjusting variable. However, there are two exceptions. First, if prices are slow to adjust relative to the country’s holdings of international reserves, then a deficit country might choose to adjust the peg to a lower value of the country’s currency (“depreciate the currency”). Second, the typical “fixed rate” has upper and lower gold (more generally, specie) points, parity points, or support points. The exchange-rate continuum between these upper and lower points (called, for example, the “gold-point spread” or “parity band”) constitutes a floating rate, and causal PPP is free to operate within this continuum.

If mutual causation is significant in each direction (a strong feedback mechanism), or if causation from the exchange rate to prices is dominant, then “causal PPP” breaks down. However, “equilibrium PPP” is not adversely affected. Indeed, mutual causation (with feedback) between exchange rate and prices enhances the validity of “equilibrium PPP,” providing there is stability of the exchange rate and prices (or inflation)—as again would be the case under responsible monetary policy.

Many limitations of PPP theory involve price levels (or indexes) as not the only systematic influence on the exchange rates. These other variables that determine the exchange rate, or that enter the equilibrium relationship of the exchange rate and prices, constitute elements of the X vector in the G function above. If the X vector includes variables other than (or in addition to) lagged E or lagged P, then the associated PPP theory may be said to be “biased.” The PPP theory is “non-exclusive,” or “augmented (with other variables)” (the term suggested by Officer, 1982, p. 188).

Is an augmented PPP theory legitimately classified within the domain of PPP? According to Officer, the answer is affirmative, providing the following criterion is satisfied: (1) the P variable (presumably including its lagged values) is the *most important* explanatory variable for E, or the most important variable in the equilibrium relationship for E.

Weaker criteria are possible; for example, (2) the P variable playing merely a significant role in the G function. Stronger criteria are also possible; for example, (3) no variable other than P significant in the G relationship.

PPP is a monetarist theory, and the monetarist credo is that, at least in the long run, real variables are not affected by monetary variables, nor are monetary variables affected by real variables. This doctrine can be applied in various ways. Usually, the money stock for each country is a determinant of the country's price measure via the quantity theory (another monetarist proposition). Thus money only indirectly affects E. However, it is within the PPP rubric for the money stock to enter the E equation directly as an explanatory variable in addition to P; for all three variables are monetary. As another example, consider that R is a real variable; whence if E, the nominal exchange rate, enters the R equation, a principle of monetarism is violated and the theory is not in the PPP domain.

For univariable PPP theory, in which E and P enter combined into the real exchange rate (R), only the strong criterion (3) among those stated above makes sense; but that criterion overly restricts the PPP rubric. A possible alternative criterion is obtained by dividing the elements of X into two groups, lagged R variables and non-R variables. If the former group has greater importance than the latter, then the augmented PPP theory remains in the PPP domain.

II. Historical Application of PPP: Pre-Modern Periods

"Amidst the then prevailing conditions [in Greek and Roman times] it would be clearly absurd to entertain any notions that purchasing power parities had any influence on exchange rates."—Einzig (1970, p. 44)

1. background comments

The "pre-modern" period denotes human history prior to the 18th century. For the pre-modern period, the only use of PPP is to assess the extent of the integration of the domestic economy with foreign economies. The closer PPP is to fulfillment, the greater the integration. One extreme is full integration, inferred from strict absolute PPP fulfilled. The other extreme is an economy either with no contact with the outside world (a closed economy) or with contact that does not involve a relationship between the exchange rate and domestic prices. There are three ways of using PPP to determine the amount of integration of economies:

1. Test PPP theory statistically. This is the ideal method of using PPP to assess integration—but is not possible for pre-modern economies, because of lack of data.

2. Observe individual-commodity price differences, in domestic currency, at home and abroad. This technique is usable, even in the absence of recorded price series; for (i) contemporary authors may have written of the price differences, or (ii) inferences on price differences may be made by modern scholars based on other information.

3. Observe exchange rates and domestic prices. Again recorded data are not necessary, for reasons of the same nature as (i) and (ii) above.

Pre-modern economies are characterized by monetary systems in the realm of a coin standard. Except in China, paper standards were unknown until the 18th century. In fact, again except in China, paper money did not even exist until toward the end of the pre-modern period. Exchange rates were "fixed" at mint parities. According to Einzig (1970, p. 71), foreign-exchange transactions were almost entirely coin-for-coin until the 13th century, when bills of exchange became dominant.

The "fixity" of exchange rates was not absolute, in two respects. First, mint parities were responsive to depreciation and debasement of coins. Second, specie-point spreads were much wider than in modern times.

2. ancient period

The few scholars that have examined the issue are unanimous that there was not even a tendency for PPP theory to be fulfilled in Ancient times. Burns (1927, p. 417) writes of "the failure of the exchange to represent the purchasing power parity between Roman and foreign coins." Einzig (1970, p. 44) asserts that, in the Ancient period, "purchasing power parity was unknown and inapplicable." Officer (1982, p. 27) states that, in Roman times, "exchange rates bore no relationship to purchasing power parity." The Roman Empire is the economy with specific treatment in this respect. Together, Burns, Einzig, and Officer offer four reasons why PPP theory did not apply to the Roman Empire:

1. Roman imports were luxuries, such as valuable furs, amber, carpets, silk, precious stones, and aromatics. They were purchased only by the rich. They were income, rather than price, determined. The own-price elasticity of demand for imports was effectively zero.

2. Imports were not produced in the Empire, and had no close domestic substitutes. The cross-price elasticity of demand for imports with respect to domestic commodities was also zero, or close to it.

3. There were tremendous price differences between Rome and its trading partners. Citing the Roman historian Pliny, Einzig (1970, p. 45) reports that "merchants importing Indian goods sold them in Rome at a hundredfold of what they had paid for them…the margin between the price of luxuries in their countries of origin and in their countries of destination was [some]thing like 10,000 per cent." Such price differences are suggestive of arbitrage imperfections, which took two forms:

(a) High transportation and commission charges, inherent in the state of transportation and communication technology.

(b) High profit margins and risk premiums, for two reasons: (i) a limited number of entrepreneurs prepared to provide travel and transportation services to foreign lands over vast distances, with the time loss and physical dangers (loss of goods, loss of life) that such travel entailed; (ii) possible monopoly elements in foreign trade: the Roman emperor had the power to encourage or discourage foreign trade and voyages.

4. Trade in non-monetary commodities between the Roman Empire and Asia was largely one-sided. Rome imported luxury goods, as stated above; but exported non-monetary commodities to the Far East only in small amounts. Two reasons have been offered for this one-sided nature of trade.

(a) Far Eastern countries had little demand for wine, oils, wool manufactures, and leather manufactures—which were the Empire's principal exportables. This is the conventional explanation.

(b) Roman non-monetary commodities were priced out of the Eastern market. The reason was a high Roman price level, itself a result of coin debasement and overissue, that was inconsistent with PPP. This explanation is offered by Burns, but is rejected by Einzig.

Irrespective of the reason for the one-sided trade, Rome did have an abundant exportable that was in demand in the East: silver. The Empire's silver was acquired in three ways: as tribute from conquered regions, via taxation within the Empire, or directly from mining. Therefore Rome paid for its imports by exporting silver. To the extent that silver exports were in the form of coin, Rome thereby financed its "balance-of-payments deficit on commodity account." To the extent that the silver was bullion, it can be considered a normal commodity export, reducing the one-sided character of Roman-Eastern trade.

In sum, the economy of the Roman Empire may have been well integrated within itself, but certainly not with the outside world.

3. medieval period

Einzig (1970, p. 99) states that "in the Middle Ages…exports and imports were largely inelastic and unresponsive to changes in prices or exchanges." Officer (1982, p. 28) suggests reasons for this inelasticity:

1. The feudal economy, with its self-sufficiency nature and structured society, had purely luxury imports, as in Roman times.

2. General contraction of trade occurred, both within Europe (the former Roman Empire) and between Europe and Asia.

The result was again inapplicability of PPP and lack of integration between economies, even within Europe. However, over time, trade expanded and parts of Europe coalesced into sovereign regions. Trade among these entities took place, and foreign-exchange markets developed. What used to be intra-Empire trade became foreign trade, with distances and risks less than they had been for Empire-Asian trade. It is reasonable to presume that commodity arbitrage gradually became less imperfect over time, and that there was an increasing tendency toward PPP, as economies became more integrated. This tendency must have been fostered during peace, but reversed during wartime.

4. sixteenth-century Spain

In the 16th century, Spanish scholars of the Salamanca School originated the PPP theory. In their environment, PPP was an indicator not only of integration of the Spanish and outside economies but also of the importance of monetary influences on the exchange rate. Among the reasons for the Salamancan invention of PPP theory were their empirical observations:

1. Spain had received large inflows of gold and silver from the New World; it was the first country in the Old World so favored.

2. Consequently, the Spanish money stock increased.

3. The Spanish price level also increased.

4. Exchange rates had become unfavorable to Spain. Spain (along with England and the rest of Europe) was on a metallic standard. Therefore, what an unfavorable movement in exchange rates meant was a movement in current exchange rates away from mint parities in the direction of specie-export points. This was a lower exchange value for Spanish coin.

The equilibrium relative-PPP theory was fulfilled, at least in an approximate sense. The causal PPP theory was also satisfied, with the obvious causal chain 1→2→3→4. Some Salamancan writers, in particular Azpilcueta de Navarro and Domingo de Bañez, stated the PPP theory implicitly or explicitly, as a consequence of this chain. For details, Officer (1982, pp. 30-33) and the pioneering studies of Grice-Hutchinson (1952, 1978) may be consulted.

III. Methodology of Testing PPP Theory

"Each analyst will have to decide in the light of his own purposes whether the PPP relationships fall close enough to 1.00 to satisfy the theories."—Kravis and Lipsey (1978, p. 214)

1. characteristics of studies surveyed

For the modern period, meaning from the 18th century onward, data are available for testing PPP theory. Also, the extent to which PPP theory is fulfilled has several implications for a given historical experience: integration of domestic and foreign economies, importance of monetary relative to real variables in macroeconomics, role of fundamental factors ("fundamentals"—represented by PPP) relative to speculation in exchange-rate determination.

A tremendous number of PPP studies for the modern period exists. To examine all these studies is unmanageable. Even for the subset that will be investigated, some ordering of the studies must be imposed. Also, the surveyed studies share some characteristics. Consider the following elements, criteria for inclusion:

<u>criterion 1: time period:</u> To be considered in the historical domain, and therefore surveyed in this essay, the study's time period must fully antedate the Bretton Woods system (established in 1947). That is an arbitrary bar separating "history" from "post-history." Obviously, the bar would move forward as time goes by. The arbitrariness of the bar is not complete; several reasons exist for that selection of separation year:

1. The Bretton Woods system was one of fixed exchange rates, an exchange-rate system for which PPP investigation holds less interest to scholars than a floating exchange rate. So there are relatively few PPP investigations for the Bretton Woods period (1947-1973). Following Bretton Woods, floating exchange rates became prevalent and the number of PPP investigations exploded to the point that their inclusion would make this survey unmanageable.

2. In effect, the dividing line becomes the advent of World War II, as there are no PPP studies (nor would they be particularly meaningful) for the war years as such. World War II is also a natural demarcation point. Therefore 1939 is the last year of interest in this survey.

3. There exist some excellent PPP surveys of the post-Bretton-Woods floating rate period, but no comprehensive survey of the pre-Bretton Woods period.

4. While the number of PPP studies with time period antedating Bretton Woods is very large, it is not overwhelmingly so. Therefore a comprehensive survey is possible—and such a survey is performed here.

5. The many fixed-versus-floating exchange-rate divergent time periods prior to Bretton Woods enable a logical ordering of the studies.

<u>criterion 2: exchange-rate regime:</u> The studies are organized according to historical episodes. The plan is that each episode falls within a specific exchange-rate regime (fixed or floating rate). Exceptions are (i) the interwar period, for which the time period is permitted to incorporate more than one regime; and (ii) periods of predominantly, even though not exclusively, floating exchange rate.

Some studies have a lengthy time period, extending over a century or more, and incorporating several exchange-rate regimes. Such studies are included here only if the findings are divided into subperiods; in that case the subperiods are included if they satisfy both criteria 1 and 2.

<u>criterion 3: economic entity:</u> The subjects ("domestic economies") of the included studies are countries or colonies. PPP studies involving cities as such are excluded; an example would be investigations of the LOP among major cities of a given country. Actually, given the time-period restriction (criterion 1), the economic-entity exclusion happens virtually by default.

<u>criterion 4: application:</u> PPP as a computation has various applications; but included here are only studies that employ PPP to examine the exchange rate. Therefore excluded, for example, is PPP used for international comparison of output or of productivity. Also

excluded are studies of the LOP for individual commodities, as such investigations are micro rather than macro in nature. Again, given the time-period restriction, these exclusions happen almost by default.

criterion 5: PPP variable: In principle, studies of either absolute PPP or relative PPP are admissible. However, because of lack of absolute PPP data prior to 1950, only investigations of relative PPP are included. This is not a criterion, but rather a reflection of data availability. For absolute PPP, one would need measures of *absolute* prices, price levels; and these are rare even after 1947. For relative PPP, one requires only price *indexes* in the countries considered.

criterion 6: base country: The base (or foreign) country has one of the following characteristics.

1. It is the domestic-country's most-important, or one of the most-important, trading-and-payments partners.

2. It is the most-important, or one of the most-important, countries in world trade and payments.

This criterion is naturally met by every PPP study; so it is not restrictive. Of course, characteristics 1 and 2 need not be mutually exclusive. Also, a study may use, as alternatives, several alternative base countries, each with the given characteristic. Further, the effective exchange-rate concept may be used: the exchange-rate index and price index of the "base" entity are weighted averages of exchange-rate indexes (with respect to the domestic currency) and of price indexes, respectively, of the domestic-country's main partners in trade and payments.

criterion 7: price index: Various price measures have been used in relative-PPP computations. Ranging from most-justifiable to least-justifiable (with symbols), they are as follows: GDP deflator (PGDP), GNP deflator (PGNP), consumption deflator (PCONS), retail price index [incorporating consumer price index and cost-of-living index] (RPI), wholesale price index (WPI), export price index (XPI), wage-rate index (WI), component indexes or sub-indexes of WPI or RPI, and prices of individual commodities.

The bar separating included from excluded price measures is drawn between WPI and XPI. So results based on PGDP, PGNP, PCONS, RPI, and WPI are included in the survey; those based on the other measures are excluded. The criterion is applied judiciously. Thus a study that employs a variety of alternative price measures may have some of its results included, other of its results excluded. Rationale for the placement of the separation bar follows.

PGDP and PGNP have three justifications. First, as stated by Cassel (1928, p. 33), PPP relates to the internal value of currencies, and therefore should be "measured only by general index figures representing as far as possible the whole mass of commodities marketed in the country." PGDP and PGNP fit this criterion better than any other price index. Second, PPP is a macroeconomic theory, and therefore necessitates the usual macro price concept, PGDP or PGNP. Note that these price measures differ only because the first excludes, the second includes, the effect of net factor income from abroad. PGDP is marginally preferred, because it measures the price of production within the country. Third, to the extent that PPP is justified by arbitrage and substitutability of commodities in production and consumption (broadly construed), the price concept underlying PPP should be as broad as possible, again leading to PGDP or PGNP.

In addition, PGDP has a firm theoretical foundation based on economic modeling: for absolute PPP founded on a “unit-factor-cost parity,” each country’s own pattern of production provides the ideal weights for the country’s price measure (Officer, 1982, pp. 200-203, 250-251). The move to household-consumption weights—whence PCONS and RPI—can be justified via some assumptions (Officer, 1982, pp. 203, 204), although PCONS and RPI have the limitation of excluding non-consumables from the index.

Cassel (1924, pp. 438-439) actually preferred the WPI to the RPI, and used the former index in his empirical work. The reason he gave was the high degree of homogeneity for commodities in the WPI, in contrast to the wide variation in quality for commodities in the RPI. However, Cassel’s ranking of the two index numbers is wrong. Other things being equal, one would like to place WPI below the separation bar (while leaving the RPI above the bar). There are two reasons for this preference. First, as pointed out originally by Keynes (1930, pp. 72-74; 1931 [originally published in 1925], pp. 249-250), a PPP computed from traded-goods prices alone is close to a truism. Because (i) in any given country, the WPI is heavily weighted with tradables and, in particular, excludes all services, and (ii) across countries, arbitrage directly equates prices of tradables (up to transactions costs, including tariffs and transportation charges), a PPP computed from WPIs comes close to making PPP theory a truism. More generally, the WPI biases results in favor of the hypothesis that PPP theory holds, and therefore that the domestic economy is well integrated with the foreign economy. In contrast, the RPI consists of nontradables (services) as well as tradables.

Second, the weighting pattern of the WPI need not bear a close relationship to the production-weighted (that is, GDP weighting pattern) of the economy. The WPI incorporates considerable, but unknown, double-counting and even multiple-counting. Again in contrast, the RPI has a logical weighting pattern.

Yet, unfortunately the most widely used price measure in PPP studies is the WPI. Excluding findings based on WPI would mean abandoning a high percentage of all work on PPP, especially investigations of the pre-Bretton Woods period. For many historical periods, the WPI is the only, or at least the most-comprehensive, price index available. Even when alternative indexes exist, researchers often select the WPI. So, on grounds of expediency, the WPI just makes the bar. One makes that decision with fear of regret.

The XPI is totally composed of tradables. After the joyless decision to include the WPI above the bar, it gives one a certain pleasure to place the XPI below the bar. Also, price measures of individual commodities are excluded, because of their lack of comprehensiveness.

Wage-rate indexes (WI) are excluded, primarily because PPP theory (and its justifications) pertains to prices of commodities rather than of factors of production. Cassel (1924, p. 439) wrote: “Wages must not be taken into account [in the index number for PPP], because, as the share of the worker in the total amount of the national production, they normally rise, even when the prices of commodities do not, in an advancing economy.” This is not to deny that factor prices are important ingredients in prices of commodities and therefore important influences on the exchange rate. Indeed, that relationship underlies the unit-factor-cost theory of PPP (mentioned above), and Cassel (1922, p. 144) himself states: “The level of wages in the country, therefore, is always a very important factor—in the long run may be the predominating one—in determining the international value of the country’s currency.”

A second reason to exclude WI is the opposite justification for excluding XPI (and only reluctantly including WPI). In contrast to measures heavily weighted with tradables, that can move almost automatically in correspondence with the exchange rate, WI is typically the price of an entity heavily nontradable, and can move *too slowly* relative to the exchange rate.

2. forms of PPP hypothesis

specification: Building on equation (9), consider the equation

$$\log E_t = \alpha + \beta \cdot \log p^d_t + \gamma \cdot \log p^f_t + u_t \qquad (13)$$

where α is a constant term and u_t is an “error-in-equation” in period t. Equation (13) is a trivariate equation, and allows for several tests of PPP. If $\beta > 0$ and $\gamma < 0$, then PPP in its weakest, trivariate, form is fulfilled. If $\alpha = -\log E_0$ (a test nowhere reported in the public domain, to the best of my knowledge), the base-period property of relative PPP is fulfilled. If $\beta = -\gamma$, there is “symmetry” of the effects of the domestic and foreign price variables, and the theory is bivariate. If $(\beta, \gamma) = (1, -1)$, there is “proportionality” of the effects of the price variables, and theory is univariate.

Instead of testing for restrictions, they can be imposed. Bivariate PPP has the form

$$\log E_t = \alpha + \beta \cdot \log P^{r1}_t + u_t \qquad (14)$$

where, it is recalled, $P^{r1}_t = p^d_t/p^f_t$. Again testing can proceed. The (neglected) test of the parameter α is the same as for equation (13). Bivariate theory holds for $\beta > 0$. If $\beta = 1$, the theory is univariate.

Univariate PPP is typically imposed via the equation

$$\log R^{r1}_t = \alpha + u_t \qquad (15)$$

where $R^{r1}_t = E_t/P^{r1}_t = E_t \cdot (p^f_t/p^d_t)$, in which the parameter α can be tested as before (though again such testing has never been reported). A high explanatory value of the equation supports the constancy (α) of the real exchange rate. In principle, an alternative univariate equation is

$\log R^{r2}_t = u_t$ (16)

where, it is recalled, $R^{r2}_t = E_t/P^{r2}_t = (E_t/E_0)\cdot(p^f_t/p^d_t)$. Equation (16) incorporates the restriction $\alpha = -\log E_0$. Even so, equation (16) may include a constant term, the zero value of which can be tested.

Because of "errors in variable," in particular, differential imperfections in the price indexes (p^d_t and p^f_t) relative to the "ideal" concept (PGDP), symmetry and (especially) proportionality cannot be expected to hold exactly. So (14) – (16), the bivariate and univariate equations, inevitably involve a specification error in that the incorrect price variable is used. If the error rather is interpreted as an "error in variable," with P^{r1}_t measured with error, then—as shown by Theil (1971, pp. 608-609)—the ordinary-least-squares estimator of β in equation (14) is biased downward. This bias generally increases the probability of type I error (rejecting the null hypothesis $\beta = 1$ when true).

However, the trivariate equation has a problem of its own. The domestic and foreign price indexes may move in close correspondence, resulting in harmful multicollinearity. In practice, most PPP investigations are bivariate or univariate.

A special form of PPP specification imposes the restriction $\gamma = 0$, in equation (13). Studies of this nature are included in the survey. In effect, the foreign price variable (p^f_t) is either assumed fixed or considered of relatively low variation compared to the domestic price variable (p^d_t).

<u>other variables:</u> In the survey, augmented-PPP investigations incorporate such variables as capital flow, interest rate, income, and money stock. A variable is included under this heading only if the variable is treated quantitatively by the author and is integrated with the PPP test.

<u>equilibrium versus causal relationship:</u> The PPP relationship tested can either be an equilibrium relationship or a causal relationship, each being tested directly. A hybrid test involves an equilibrium relationship tested via an imposed causal relationship. The causal direction is indicated by the direction of minimization of the sum of squared errors in regression. Equations (13)-(14), and in principle (15)-(16), are of this ilk, with minimization in the direction of the exchange rate.

Some scholars believe that this direction of minimization is applicable only to a floating exchange rate. Under a fixed exchange rate, the "dependent variable" is p^d_t and the "independent variable" ($E_t\cdot p^f_t$): the domestic price index is determined by the foreign price index expressed in domestic currency, the "world" price index governing the domestic price. However, the Casselian tradition and indeed Cassel himself saw PPP as the principal determinant of the exchange rate under both a floating exchange rate and the gold standard (see the references in Officer, 1982, p. 194, n. 22). PPP theory implies that, in the long run, gold points (or market-intervention points) must envelop the PPP for the country to avoid unsustainable losses or gains of international reserves.

Testing of an equilibrium relationship is discussed in the next section. In modern work, testing for causality involves a peculiar definition of causality: Granger causality. The philosophical, and common-sense, definition of causality ($\log P^{r1}_t$ causing $\log E_t$, for example) involves $\log E_t$ effected by $\log P^{r1}_t$; the value of $\log E_t$ determined by the value of $\log P^{r1}_t$. Granger causality is different. Consider the equation

$$\log E_t = \alpha + \Sigma_i\, \beta_i \cdot \log E_{t-i} \;+\; \Sigma_i\, \gamma_i \cdot \log P^{r1}_{t-i} \;+ u_t \qquad i = 1,\ldots j$$

The value of j is set to reduce the error, u_t, to white noise (zero mean, constant variance, zero autocovariances), but no higher a value. $\log P^{r1}$ does not Granger-cause logE if the γ_i parameters all equal zero. If at least one of the γ_i is nonzero, then $\log P^{r1}$ does Granger-cause logE. So Granger causation is a forecasting concept. If $\log P^{r1}$ aids in the forecasting of logE, then it is said to Granger-cause E. Only preceding values of $\log P^{r1}_t$ can assist in the forecast; and they can only assist: lagged values of $\log E_t$ are also in the forecast equation, via the β_i parameters.

3. techniques of testing

comparative-static computation: An obvious test of PPP theory, and the one first employed by Cassel, is to compute P^{r2}_t ($=P^{r1}_t \cdot E_0$, where $P^{r1}_t = p^d_t/p^f_t$) for either one period t, a few discontinuous periods t, or a continuous sequence of periods over t. These are all termed "comparative-static" computations, although the last involves generation of a time series. The computed P^{r2}_t are then compared with the corresponding values of E_t. Alternatively, R^{r2}_t ($= E_t/ P^{r2}_t$) is compared with unity. In either case, the closer the computed value to the norm, PPP-predicted, value, the closer is PPP theory to fulfillment. Any noticeable divergences between P^{r2}_t and E_t, or of R^{r2}_t from unity, are then explained in terms of non-PPP influences on the exchange rate (augmented-PPP theory).

A graph of the two time series, or of the real exchange rate against unity, is sometimes used to enhance drawing conclusions. Also, one can allow for a lagged effect of P^{r2} on E. Further, investigations of lead-lag relationships are used to test the PPP-postulated direction of causality, from prices to the exchange rate. The base period can be the initial time period in the comparison, the entire time period, or a period antedating that time period (for example, a 1913 base year for investigations of the 1920s).

regression: Visual inspection of figures, whether in tables or graphs, has the disadvantage that interpretation of relationships among variables is subjective, absent formal statistical analysis. Therefore researchers came to use regression analysis to test PPP theory, employing equations such as (13) – (15). Then it came to be realized that regression analysis (and also, implicitly, visual investigations) ignored crucial time-series properties of variables, so that results and conclusions could be meaningless or spurious. A summary of pertinent time-series analysis is in order. Excellent texts on the subject are Hamilton (1994), Enders (2004), and Wei (2006); the discussions in Stokes (1997) and Greene (2003) are also useful.

Consider the general time-series process for variable y:

$$\phi(L)\cdot[(1 - L)^d \cdot y_t] = \theta(L)\cdot e_t \qquad (17)$$

where L is the lag operator [for example, for d = 1, $(1 - L)y_t = \Delta y_t = y_t - y_{t-1}$], $\phi(L)$ and $\theta(L)$ are autoregressive and moving-average polynomials in L, $d \geq 0$, and e is a white-noise error or innovation term. y_t is a stationary series if it has a constant and finite mean, a constant and finite variance, and convariances that are constant for a given time interval between the observations. The comparative-static and regression studies of PPP implicitly assume stationarity of the PPP, nominal-exchange-rate, and real-exchange-rate series that are utilized.

Assume that $\phi(L)$ and $\theta(L)$ do not give rise to nonstationarity or non-invertibility, respectively; that is, the roots of these polynomials are "outside the unit circle." The value of d—one can think of this as the lowest value of d—for which y_t is stationary is called the "order of integration" of y, and y is said to be I(d), integrated of order d. *Most time-series studies of PPP consider only integer values of d.* Then d indicates the number of times that y_t must be differenced in order to achieve a stationary series.

If d = 0, y_t is stationary and called I(0) or an ARMA (autoregressive moving-average) series. If d = 1, y_t is nonstationary with one unit root (first-differencing y_t makes the series stationary); y_t is I(1). If d = 2, y_t is nonstationary with two unit roots (second-differencing y_t results in stationarity), and y_t is I(2). Often it is assumed that $\phi(L) = \theta(L) = 1$; then, for d = 1, equation (17) reduces to a random walk:

$$(1 - L)\cdot y_t = \Delta y_t = y_t - y_{t-1} = e_t \qquad (18)$$

Series characterized as I(0) have several desirable properties. (1) As a stationary series, computation of the parameters (mean, variance, autocorrelations) of the series is readily accomplished from sample data. (2) As a stationary series, y_t exhibits "mean reversion": at least in the long run, the series returns to its mean, the equilibrium value of the series. Deviations of the series from its mean are only temporary. Shocks to the series have only temporary effect. (3) An I(0) series has the possibility (though not the necessity) of "short memory," meaning that, when the $\phi(L)$ polynomial is inverted, the resulting moving-average representation of the series has coefficients that decay relatively rapidly. After a few lags, autocorrelations of a short-memory series die out. The implication of short memory is a relatively fast reversion to the mean, after any disturbance. (4) There is no statistical reason why regressions or correlations involving only I(0) series would be spurious. The legitimacy of standardized tests for significance stands.

Traditionally, economists have an either-or viewpoint of stationarity: a series is either I(0) or I(1): it is stationary without any differencing, or has one unit root. Rarely, an economic time series is considered I(2), perhaps under hyperinflation. The conventional wisdom has been that most economic series are I(1)—and I(1) series have disadvantages. (1) They lack a constant mean; or, if they have such a mean, have a non-constant or even infinite variance. Estimation of parameters of the series cannot be readily effected. (2) Mean reversion is not present. There is no mean to which to revert; or deviations from a mean persist. (3) Memory is infinitely long; the "stochastic trend" emanating from disturbances adds new terms without reducing the impact of existing terms. (4) Regressions and correlations can be spurious with even one of the variables I(1), and standard tests of significance give misleading results.

The integer restriction of the parameter d, the I(0)-I(1) dichotomy, has been relaxed by some econometricians and some econometrics users, including investigators of PPP. They incorporate fractional values of d, $0 < d < 1$ in equation (17). These, "fractionally integrated," series are mean-reverting, but have long memory. It takes a long time for the effects of disturbances to die out; autocorrelations of the disturbances decay very slowly. The critical value for d is ½. For $d < ½$, the process is stationary; for $½ \leq d < 1$, the process is nonstationary, because the variance of y_t is infinite. In the latter case, stationarity is obtained by first-differencing the process. For correlations or regressions involving two fractionally integrated variables, say of orders $I(d_1)$ and $I(d_2)$, spurious results occur for $d_1 + d_2 \geq ½$.

<u>Testing for stationarity:</u> Clearly, it is important to test variables for stationarity. Investigators of PPP have applied the same tests as other researchers: augmented Dickey-Fuller, Perron of various types, and variance-ratio. These tests involve I(1) as the null hypothesis and I(0) as the alternative hypothesis, and are notorious for their low power [probability of rejecting a unit root when the true series is I(0)]. Occasionally a researcher uses the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, which has I(0) as the null and I(1) as the alternative.

Modern univariate testing of PPP (meaning testing of PPP in the form of the real exchange rate) involves testing for the stationarity, specifically I(0), of the real exchange rate, $R^{r1}{}_t$, as distinct from testing for a constant mean (as was formerly done). If the null of a random walk cannot be rejected, then PPP theory fails; for a disturbance never dies out, but rather is simply added to the stochastic trend. If the null of a random walk is rejected (or if, under a test such as KPSS, the null of I(0) is accepted), then there is an equilibrium value of the real exchange rate to which the actual value reverts in the long run. Deviations of the actual from the equilibrium (mean) real rate do occur, but they eventually disappear. This test of PPP is pleasing, because it treats the theory as applicable only to the long run; but the test is also displeasing, because (1) it does not impose a PPP-determined mean value, and (2) it does not test for symmetry or proportionality. In other words, an extremely weak interpretation of PPP is tested.

It used to be thought that ex-ante PPP is destructive of traditional PPP. The argument is as follows. Equation (12) can be rewritten in terms of the real exchange rate. Recalling that $R^{r1}{}_t = E_t \cdot (p^f{}_t / p^d{}_t)$, taking logarithms, then changes in logarithms, and applying $\Delta X_t / X_t \approx \log(1 + \Delta X_t / X_t) = \log(X_{t+1}/X_t) = \Delta \log X_{t+1}$, it is seen that equation (12) becomes:

$$EV(\Delta \log R^{r1}{}_{t+1}) = k \qquad (19)$$

Now assume that the real interest-rate differential is not a constant but rather has expected value of a constant (K) via rational expectations:

$$EV(k_{t+1}) = K + u_{t+1} \qquad (20)$$

where u_{t+1} is white noise. Then equation (19) yields

$\Delta \log R^{r1}{}_{t+1} = K + u_{t+1}$ or

$$\log R^{r1}_{t+1} = \log R^{r1}_{t} + K + u_{t+1} \qquad (21)$$

Thus the real exchange rate is a random walk with drift (K); it is I(1). It follows that there is no mean reversion of the real exchange rate. PPP does not hold in the long run. That result is devastating to traditional, Casselian PPP theory.

Fortunately, Taylor and Sarno (2004), in a brilliant paper (on which the derivation of equation (21) is based), rescue traditional PPP. They show that stationarity of the real exchange rate results from reasonable forms of the ex-ante PPP model, providing only that the expected real-interest-rate differential is not identically equal to a constant. For example, if a real appreciation of the country's currency has a long-run deflationary effect on domestic prices, then the real exchange rate is stationary.

If trivariate or bivariate PPP is tested, say via equation (13) or (14), and the variables (or at least one of them) involved are found to be I(1), then spurious regression might be present. According to Hamilton (1994, pp. 561-562), there are three alternative cures. First, include lagged values of the dependent and independent variables as explanatory variables in the regression. Second, use generalized least-squares (GLS), in the form of first-order autoregression, AR(1), such as the Cochrane-Orcutt procedure, to adjust for first-order autocorrelation in the residuals. Third, first-difference the variables.

It is possible that a transformation short of first-differencing might work, for example, taking logarithms of the variables. Also, including only the lagged dependent variable as an explanatory variable might be sufficient. While early studies of PPP paid no attention to stationarity, some did make an adjustment—perhaps inadvertently or for some other reason (usually hypothesis specification). The better procedure, of course, is to precede any action with formal testing for order of integration of the variables.

<u>Cointegration analysis:</u> Even if variables are tested and I(1) cannot be rejected, one should not proceed with correcting for spurious correction; for the variables might be cointegrated, that is, a linear combination of the variables is I(0). Cointegration analysis is admirably suited for PPP bivariate or trivariate testing. The cointegration model involves the PPP relationship, equation (13) or (14) with zero error, as holding in the long-run: it is the long-run equilibrium. Deviations from that relationship occur in the short run, and an error-correction process returns the variables to the long-run relationship: there is mean reversion. Differing speed of adjustment for the exchange rate and for price (or price ratio) is embedded in the error-correction process. Symmetry and proportionality are not imposed, and can be tested. General-to-specific modeling, in which restrictive models are nested within more-general models, can be used here, as with conventional regression analysis. The causal aspect of PPP can also be tested, via the speed-of-adjustment coefficients. Fractional cointegration, involving fractionally integrated variables, is also possible, though rarely performed in the PPP literature. Fractional cointegration is more general than integer cointegration, because the linear combination of the variables is not restricted to I(0) but can be I(d), where $0 < d < 1$.

First-differencing without testing for cointegration is exceedingly dangerous. If the variables are I(0), the underlying economic theory is violated. If the variables are I(1) and cointegrated, the long-run relationship is discarded. The advantage of cointegration is that it retains the low-frequency (long-run) relationship and incorporates high-frequency (short-run) adjustment to this relationship.

IV. Modern Period: Testing of PPP

"Actual exchange rates of, say, half or twice parities calculated in any plausible manner are highly unusual, yet if there were nothing at all to the parity doctrine, actual exchange rates of only a few percent or of several hundred percent of calculated rates would not uncommonly appear by chance."—Yeager (1976, p. 219)

The principal use of PPP in historical research of the modern period (18^{th} century onward) is testing the validity of the theory. Although almost all investigators test the theory for its own sake, in effect the degree of integration of the domestic with the foreign economy is assessed. Most, but not all, studies pertain to periods of a floating as distinct from fixed exchange rate. An attempt is made to cover all studies that meet the seven criteria in section III.1 (with apologies due to authors whose studies are omitted); but, to be included in the survey, a study must indeed meet the criteria.

The periods examined are grouped into nine categories: (1) early North America, (2) bullionist periods, (3) floating rates—second-half of 19^{th} century, (4) classic metallic standards, (5) World War I, (6) floating rates—1920s, (7) 1930s, (8) interwar period: fixed and floating rates, (9) miscellaneous periods, long-term. Note that (1)-(7) are basically ordered chronologically, from the earliest period to the latest; while (8) conjoins (6) and (7), and (9) is a miscellaneous category. Studies are summarized in tables, with multiple tables for some groups; and a given study may fit in more than one category and so appear in more than one table. Within a table (or within a grouping in a table, for a table arranged into groups), studies are identified by author and ordered chronologically.

The various studies are weighed equally in the tables. This treatment does not mean that this reviewer considers all studies to be equally valid or important. Certainly, if a study pays no attention, or insufficient attention, to the issue of nonstationarity, then the results of the study must be viewed with caution. In this respect, the reader is invited to consider the "Nonstationarity" columns in the tables. Empty cells under the columns, or absence of the columns, suggests that results of the pertinent studies could be spurious.

This reviewer also believes that there is a hierarchy of price indexes for PPP, as delineated in criterion 7 of section III.1. Results of studies based on price measures higher in the hierarchy might be deemed of greater validity, other things being equal. The table identifies the price index or indexes for each study.

Nevertheless, each and every study adds to historical knowledge to some extent, and readers will have to decide for themselves how much of the results to take from each table and how to weigh the results of a particular study within a table.

1. early North America

Table 1 summarizes PPP testing for early North America, divided into three periods. The earliest date of any PPP testing in this survey is the U.S. colonial period, that is, prior to 1776. Three of the studies of this period relate to British colonies in the future United States; one pertains to Lower Canada (Quebec). Bordo and Marcotte (1987) investigate South Carolina (SC) under a fixed exchange rate. The exchange rate was not rigid, with temporary devaluations of parity. Two exchange-rate series are used; one is the par value, the other is based on bills-of-exchange. The latter is preferred by the authors, as the series includes such additional elements as risk premium and implicit interest. A unitary elasticity of the SC price index with respect to the SC-currency-denominated British price index cannot be rejected. Bordo and Marcotte (1987, p. 320) conclude: “these results cannot reject the hypothesis that purchasing-power parity prevailed between South Carolina and Great Britain in the mid-eighteenth century.”

Table 1
Testing of PPP Theory: Early North America

Study	Time Period	Colony or Country	Base Country	Specification[A]	Nonstationarity		Technique	Result
					Test	Other		
I. U.S. Colonial Period								
Bordo, Marcotte (1987)	1732-1774 (A)	South Carolina	England	bivariate[B,C]		first-difference, logs	regression (ec)	positive
Choudhry, Luintel (2001)	1727-1775 (A)	Pennsylvania	England	univariate[B]	VR (rur), GPH (crur)			mixed
Grubb (2003)	1748-1775 (A)	MA, NY, PA, MD, VA, SC	England	univariate[B]	ADF (rur)	logs		positive
Grubb (2005)	1762-1775[D] (A)	Lower Canada	England	univariate[B]	ADF (rur)	logs		positive
II. Continental-Congress Period								
Bernholz (2003)	1776-1781 (M).	United States	none	bivariate[E]			graph (e)	negative
III. U.S.-Constitutional Period								
Grubb (2003)	1797-1811 (A)	MA, NY, PA, MD, VA, SC	England	univariate[B]	ADF (crur)	logs		negative
Grubb (2005)	1797-1811 (A)	Lower Canada	England	univariate[B]	ADF (mixed result)	logs		mixed

A = annual, M = monthly
ADF = augmented Dickey-Fuller, VR = variance-ratio, GPH = Geweke and Porter-Hudak
crur = can’t reject unit root, rur = reject unit root,
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship
[A]Price variable always WPI (wholesale price index).
[B]Exchange rate: number of units of domestic currency per pound sterling.
[C]Other variables: crop failure (dichotomous)
[D]For PA, also including 1785-1790.
[E]Exchange rate: dollar price of specie, price variable for United States only.

Choudhry and Luintel (2001) examine Pennsylvania under a floating exchange rate. Only their results involving a general (as distinct from commodity-specific) price index for the colony are considered here. The variance-ratio test, rejecting a unit root in the real exchange rate, is supportive of PPP. The Geweke and Porter-Hudak test, though unsupportive of PPP, is interesting, because it posits a fractional-integration model.

Grubb (2003, 2005) investigates colonies under various monetary and exchange-rates standards. He notes that, of the six American colonies examined, only Massachusetts was not on a paper standard; and that Lower Canada was on a specie standard (with no fiat paper money or banknotes). With Massachusetts and Lower Canada on specie standards, they were clearly on fixed exchange rates; but whether the five remaining American colonies had "fixed" or "floating" exchange rate is a subject of controversy among monetary historians. What Grubb calls "PPP" is actually the real exchange rate. For some colonies, a structural-break dichotomous variable is included. A unit root is rejected for all colonies except Maryland. A deterministic trend was nonsignificant in all cases. It should be noted that testing for PPP constitutes only part of Grubb's interest.

The Continental Congress of the 13 colonies in rebellion and then of the United States itself under the Articles of Confederation establishes the second period. Bernholz (2003) examines the period during which Congress issued the "Continental currency." Interestingly, during this paper standard and floating exchange rate, the price of specie (silver coin—representing the exchange rate) did not increase as much as the price index. Bernholz's explanation is the war-inflicted damage on production (supply) of goods and the British blockade, which reduced the value of specie (the currency used in payment for imports).

Replacement of the Articles of Confederation by the U.S. Constitution gives rise to the third period in Table 1. The U.S. colonies, though with their specific price indexes, are all on a fixed exchange rate—that of the U.S. dollar—by default. Lower Canada is now on a floating exchange rate, by virtue of Britain abandoning the gold standard in 1797. As Grubb (2003, p. 1794) states: "PPP performs relatively better before versus after the transition to the U.S. dollar." His explanation: the Constitution's ban on state-issued currency and the switch to the U.S. dollar may have resulted in a deterioration in monetary performance. Reasons given are (1) the market preferred state-issued paper currencies, given the inflationary experience of the Continental dollar [whence the expression "worthless as a Continental"], (2) fractionally specie-reserve based banknotes, which were unregulated, came to the fore, and (3) gold inflows could not be sterilized. A strong view contrary to all this is offered by Michener and Wright (2005).

In sum, Table 1 exhibits mixed evidence regarding the PPP theory. Impressive is the fact that all authors with but one exception (Bernholz) pay attention to the issue of nonstationarity. However, authors, such as Bordo and Marcotte, who first-difference variables that without checking for cointegration are on dangerous ground, as mentioned at the end of section III.3.

2. bullionist periods

A “bullionist period” in economic history has both an empirical and an intellectual characteristic. Empirically, a bullionist period involves a paper standard and floating exchange rate that temporarily interrupt a specie standard and fixed exchange rate. Intellectually, a bullionist period carries with it a “bullionist controversy” regarding the ruling macroeconomic model of the economy. In modern terminology, the competing models are monetarist and nonmonetarist. In particular, “bullionists” were monetarists, and generally exposited a PPP theory of the exchange rate.

Two bullionist experiences that have been subject to PPP testing are the Swedish bullionist period (1745-1776) and the Engish bullionist period (1797-1821). The latter is customarily called the Bank Restriction Period, because the Bank of England’s obligation to pay cash (gold) for its note issues was restricted. It may be noted that, while paper money originated in China, banknotes were first issued in Sweden. The Swedish bullionist period began with the paper daler made inconvertible into copper bullion. Tables 2 and 3 show PPP testing for these two bullionist periods.

Table 2
Testing of PPP Theory: Swedish Bullionist Period

Study	Time Period[A]	Specification[B]	Exchange Rate[C]	Nonstationarity		Technique	Result
				Test	Other		
Eagly (1968)	1755-1766	bivariate	percent of parity			graph (e)	positive
Eagly (1971)	1745-1769	bivariate	percent of parity			graph (e)	mixed
Myhrman (1976)	1746-1768	bivariate			growth rates	graph (e)	positive
Bernholz (1982)	1755-1768	bivariate[D]	percent of parity			graph (e)	mixed
Bernholz, Gärtner, Heri (1985)	1755-1768	univariate[D]				computation of maximum, period-end real exchange rate (e)	mixed
Bernholz (2003)	1745-1769	bivariate[D]				graph (e)	mixed

e = equilibrium relationship tested directly
[A]All annual.
[B]Base entity always Hamburg, Price variable always WPI (wholesale price index), and price variable always for Sweden only.
[C]Daler per mark banco, transformation specified where applicable.
[D]Base period 1755.

Table 3
Testing of PPP Theory: Bank Restriction Period

Study	Time Period	Specification[A]	Exchange Rate	Nonstationarity Test	Nonstationarity Other	Technique	Result
Angell (1926)	1797-1818 (A)	bivariate[B]	on Hamburg, percent of parity			graph (e, c)	negative
Eagly (1968)	1797-1810 (A)	bivariate[B]	on Hamburg, percent of parity			graph (e)	positive
Myhrman (1976)	1797-1819 (A)	bivariate[B]	on Hamburg		growth rates	graph (e)	positive
Bernholz, Gärtner, Heri (1985)	1797-1822 (A)	univariate[C]	on Hamburg			computation of maximum, period-end real exchange rate (e)	mixed
Nachane, Hatekar (1995)	1802-1838 (A)	bivariate[B]	on Paris		logs	cointegration (e), Granger causality (c)	negative
Officer (2000)	1797-1821 (Q)	bivariate[B]	on Hamburg	ADF, PP (crur)	logs, first-difference	cointegration (e), Granger causality (c)	negative

A = annual, Q = quarterly
ADF = augmented Dickey-Fuller, PP = Phillips-Perron
e = equilibrium relationship tested directly, c = causal relationship tested
[A]Price variable always WPI (wholesale price index).
[B]Price variable for England only.
[C]Base period 1797.

Three authors investigate PPP for both periods. Eagly (1968, 1971)) says little about empirical evidence for PPP and makes no explicit judgment. For Sweden, he mentions only "the rising price of foreign exchange and commodities in terms of bank notes" (Eagly, 1968, p. 14). One problem is the absence of a true base period. While the price index is 100 in 1755, the exchange rate in that year is 107 percent of parity. For England, he notes "an increase in the price of bullion, foreign exchange, and commodities in terms of bank notes" (Eagly, 1968, p. 22). The evidence in Eagly (1971) is judged "mixed" for PPP by this reviewer, because, due to exchange-market intervention, the price of foreign exchange fell while domestic prices rose.

Regarding his investigation for Sweden, Myhrman (1976, p. 188) concludes: "The covariation over the whole period is close enough to have made Gustav Cassel quite satisfied with his PPP-theory." (To the best of my knowledge, Cassel did not make reference to the 18th-century Swedish experience to justify PPP. Perhaps Myhrman is arguing only hypothetically.) Myhrman observes that the relationship between price and exchange rate in the Bank Restriction Period is similar to the Swedish case.

Bernholz, Gärtner, and Heri (hereafter BGH, 1985) apply their technique to various floating-rate episodes. Among the empirical regularities that they find (not only for the Swedish and English bullionist periods but also for other experiences): (1) PPP is violated in the short run but holds in the long run. (2) Expansion of the domestic relative to the foreign money supply results in a temporary undervaluation of the domestic currency, the price of foreign exchange increasing faster than the domestic/foreign commodity-price indexes. (3) This undervaluation largely or entirely disappears when monetary policy is reversed. The BGH computation for Sweden is distinguished by use of a foreign price index, instead of implicitly assuming a constant foreign price (as do all others studies in Tables 2-3). The Bernhoz (1982, 2003) results for Sweden are consistent with those of BGH.

Turning to authors that examine the Bank Restriction Period exclusively, Angell (1926, p. 484) can find no relationship between the British price index and exchange rate. He acknowledges "a general coincidence of movements. But it is not close enough to justify [a causal relationship]." Angell is to be commended for noting that his finding is based solely on British prices, absent data on Continental price movements.

Nachane and Hatekar (1995) reject cointegration of the British price index and exchange rate. Also, they cannot reject that price does not Granger-cause the exchange rate. Their use of the exchange rate on Paris is contrary to other researchers; economic historians generally view the Hamburg exchange as more representative than Paris during the French Revolutionary and Napoleonic Wars. The Nachane-Hatekar observation period extends to 1838, which, with annual data, increases the sample size. However, the effect is a mixture of a "paper standard, floating exchange rate" with a "gold standard, fixed exchange rate."

In contrast, Officer (2000) uses quarterly data and limits the sample to the Bank Restriction Period. Another difference is that Officer engages in multivariate testing, with Bank of England notes, the price of wheat, and external military expenditure as variables in addition to the general price index and exchange rate. While Nachane and Hatekar also employ multiple variables, their testing is entirely bivariate. However, Officer's results regarding PPP are negative, and are essentially the same as those of Nachane and Hatekar.

On balance, investigations of the bullionist periods are more mixed and negative than positive for PPP. Of the early studies, Myhrman alone performs a transformation (growth rates), that could convert nonstationary to stationary variables. Only Nachane-Hatekar and Officer pay explicit attention to the issue of nonstationarity. The fact that their findings are uniformly negative for PPP is strongly suggestive that the theory did not apply to the Bank Restriction Period.

3. floating rates—second-half of nineteenth century

Two floating-rate experiences in the second half of the 19th century have received special attention in the literature, the U.S. "greenback period" and the Austro-Hungarian experience. The Civil War was already eight months old when the greenback period began. This episode of a paper standard and floating exchange rate encompasses the full years 1862-1878. From a history-of economic-thought standpoint, it is interesting that there was no contemporary "bullionist controversy" during the greenback period. This absence did not stop later writers from testing the PPP theory for that experience, and their work is summarized in Table 4.

Table 4
Testing of PPP Theory: Greenback Period

Study	Time Period	Specification	Exchange Rate	Price Variable	Other Variables	Nonstationarity		Technique	Result
						Test	Other		
Graham (1922)	1862-1878 (A)	univariate[A]	greenback price of gold	WPI[B]	capital inflow			table (e)	mixed
Kindahl (1961)	1862-1878[C] (A)	univariate[A]	greenback price of gold	WPI[D]	capital inflow			comparative-static computation, table (e); rank correlation coefficient	positive
Friedman, Schwartz (1963)	1861-1879 (A)	univariate[E]	greenback price of gold	WPI[D]	capital inflow			comparative-static computation, graph (e)	positive
Farag, Ott (1964)	1862-1878 (SA)	bivariate	greenback price of gold	WPI[D]	interest rates			regression (ec)	positive
Thompson (1972)	1862-1878 (A)	bivariate[F]	greenback price of gold	WPI[G]	capital inflow			comparative-static computation: table (e), graph (e); regression (ec)	positive
Officer (1981)	1862-1878 (A)	bivariate	pounds sterling per greenback	PGNP[D]	capital inflow, interest rate, income		logs, GLS with AR(1)	comparative-static computation, table (e); regression (ec)	positive
Bernholz, Gärtner, Heri (1985)	1861-1871 (A)	univariate[H]	greenback price of gold	RPI[B]				computation of maximum, period-end real exchange rate (e)	mixed
Enders (1989)	1862-1878 (SA)	bivariate	greenback price of gold	WPI[D]		DF (crur)		cointegration (e)	mixed
Bernholz (2003)	1861-1871 (A)	bivariate[H]	greenback price of gold	RPI[B]				graph (e)	mixed

A = annual, SA = semi-annual
WPI = wholesale price index, RPI = retail price index, PGNP = GNP deflator
GLS = generalized least-squares, AR(1) = first-order autoregression, DF = Dickey-Fuller
crur = cannot reject unit root
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship
[A]Base period 1860.
[B]United States only.
[C]Fiscal years ending June 30.
[D]Base country: England.
[E]Base period 1861-1879.
[F]Base period 1862-1878.
[G]Alternative base countries: England, France, Germany.

[H]Base period 1861.

Graham (1922) does not mention PPP, and in fact makes no formal judgment on the validity of the theory. He states that the principal determinant of the exchange rate is (1) expectations regarding a Northern victory, during the Civil War, and (2) net capital inflow, in the postbellum period. However, it is clear from his computations and the context that these influences are secondary, and come into play given the effect of commodity prices on the exchange rate. This is the position also of later authors who offer an augmented PPP theory for the greenback period. Graham (1922, p. 241) deserves credit for noticing the greater flexibility of the exchange rate (represented by the greenback price of gold) compared to commodity prices: "The price of gold in the paper basis country will reflect changes in the general situation much more quickly than will the prices of commodities," the commodity market being "less sensitive" than the gold market.

In contrast, Kindahl (1961, p. 35) is explicit that "much of the variation in the exchange rates can be explained by general price-level movements;" as is Friedman and Schwartz (1963, p. 64), who state that "movements in relative price levels account for the greater part of the movement in the price of gold." However, the positive result of Friedman and Schwartz pertains to the postbellum period. Apart from capital flows, emphasized by all the early (pre-1985) authors in the table, changes in the composition of exports or comparative advantage—the loss of cotton exports during the Civil War, new exportables after the War—are mentioned by Friedman-Schwartz and Aldrich (1973) as another influence on the real exchange rate.

None of these authors pay attention to nonstationarity; nor do Farag and Ott (1964) and Thompson (1972). The generally positive results of all these early writers are questionable; and the regression analyses of Farag-Ott and Thompson (1972) could be particularly misleading, as the estimation technique is ordinary least-squares.

Officer (1981) provides some innovations to PPP investigation of the greenback period. Instead of representing the dollar-sterling exchange rate by the price of gold, he constructs a "true" exchange-rate series (the inverse of the dollar-sterling rate) as the ratio of the gold-dollar price of the greenback to the gold-dollar price of the pound. Also, his price concept is the GNP deflator rather than the WPI. These innovations were not followed by later writers. Officer, in effect, corrects for nonstationarity in his regressions. So his positive results for PPP lend credibility to results of the earlier studies.

Bernholz, Gärtner, and Heri (1985) obtain their usual qualitative result of short-run PPP violated, long-run return to PPP. However, the maximum value of the real exchange rate is not as far above unity, and the period-end value further from unity, than their results for the bullionist periods. Bernholz (2003, p. 51) refers to Kindahl in stating: "In 1879 the price level finally about equaled the pre-war level reached by the exchange rate. Purchasing power had been re-established." However, this result does not appear to hold for his own, cost-of-living, index, as distinct from the WPI.

Enders (1989) is the only author other than Officer to address nonstationarity, and he trumps Officer because his attention is deliberate rather than inadvertent. However, Enders' results are mixed. A unit root cannot be rejected for the real exchange rate, while the U.S. and British price indexes (the latter expressed in dollars) are found to be cointegrated. The former result is unfavorable to PPP, the latter is supportive.

On balance, PPP investigations for the greenback period are consistent with PPP. There is no study the results of which are negative as distinct from positive or mixed.

Austria was on a paper standard and floating exchange rate from the mid-19th century, when it left the silver standard, until 1892, when Austria-Hungary joined the gold standard. Especially interesting is the subperiod 1879-1892, during which the paper gulden was worth more than its legal metallic content. The PPP aspect of the Austrian experience is investigated by Yeager (1969) and Myrman (1976), who reprints Yeager's graph of the exchange rate and PPP. These studies are outlined in Table 5.

Table 5
Testing of PPP Theory: Austria-Hungary, Late Nineteenth Century

Study	Time Period	Specification[A]	Nonstationarity		Technique	Result
			Test	Other		
Yeager (1969)	1867-1891 (A)	bivariate[B]		percentage changes	comparative-static computation, graph (e); correlation coefficient (e)	positive
Myhrman (1976)	1867-1891 (A)	bivariate[B]			comparative-static computation, graph (e)	positive

A = annual
e = equilibrium relationship tested directly
[A]Base country: England, price variable WPI (wholesale price index).
[B]Base period 1879-1891.

Yeager (1969) computes correlation coefficients of the exchange rate and PPP, for the variables both in level and percentage-change form. He deserves praise for expressing uncertainty as to whether "significance levels are meaningful for correlations of time-series data" (Yeager, 1969, p. 63). Taking percentage changes could produce stationarity, and the correlation coefficient is then 0.74 (significant at the one-percent level) for the 1867-1891 period and 0.52 (significant only at the ten-percent level) for the subperiod 1879-1891. These results can reasonably be construed as positive evidence for PPP. Myhrman (1976, p. 190) comments that "both prices and the exchange rate were rather stable but with a rising trend." This remark is suggestive of a possible trend-stationarity characteristic of the variables.

4. classic metallic standards

Table 6 lists tests of PPP theory in the context of classic metallic standards, which antedated World War I. It should be noted, that in accordance with criterion 2 in section III.1, a number of long-term PPP studies that include the classic gold standard as part of a longer period are excluded, because specific results for the gold-standard period cannot be extracted.

With the United States back on the gold standard in 1879 and Britain on gold since the end of the Bank Restriction Period in 1821, it is natural to examine PPP for these two countries in the context of the fixed exchange rate of the gold standard. Enders (1989) offers an identical analysis as for the greenback period. For this period, not only is there cointegration in a bivariate model, but also now a unit root in the real exchange rate is rejected. Therefore "the results for the gold-standard period are more supportive of purchasing power parity" (Enders, 1989, p. 67). In contrast, Gilli and Kaminsky (1991) cannot reject a unit root in the real exchange rate, destructive of PPP.

Table 6
Testing of PPP Theory: Classic Metallic Standards

Study	Time Period	Specification	Countries	Exchange Rate	Nonstationarity		Technique	Result
					Test	Other		
I. Gold Standard								
Enders (1989)	1879-1913 (SA)	bivariate[A]	U.S.-U.K.	taken as constant	DF (rur)		cointegration (e)	positive
Grilli, Kaminsky (1991)	1885-1914 (M)	univariate[A]	U.S.-U.K.	dollars per pound	PP, VR (crur)	logs		negative
Catão, Solomou (2005)	1871-1913 (A)	univariate[B]	4 gold-standard core[C], 4 silver-standard[D], 8 paper-standard[E]	effective exchange rate		logs	autoregression, variance decomposition	negative
II. Silver Standard								
Hasan (2004)	1860-1893 (A)	univariate[A]	India, with England base country	rupees per pound	KPSS (crs), GPH (rur), KSS (rur)			positive

A = annual, SA = semi-annual, M = monthly
DF = Dickey-Fuller, PP = Phillips-Perron, VR = variance-ratio, KPSS = Kwaitkowski-Phillips-Schmidt-Shin, GPH = Geweke and Porter-Hudak, KSS = Kapetanios-Shin-Snell
e = equilibrium relationship tested directly
crs = cannot reject stationarity, crur = cannot reject unit root, rur = reject unit root
[A]Price variable WPI (wholesale price index).
[B]Price variable PGDP (GDP deflator) preferred to RPI (retail price index) preferred to WPI.
[C]United States, United Kingdom, France, Germany.
[D]China, India, Japan, Mexico.
[E]Argentina, Brazil, Chile, Greece, Italy, Portugal, Spain, Russia.

Catão and Solomou (2005) investigate real effective exchange rates (REERs) for three groups of countries: the gold-standard core group, countries on a silver standard for at least part of their time period (1871-1913), and countries on an inconvertible paper standard for a substantial part of the period. They do not formally test for nonstationarity of the real exchange rate of the countries; rather they accept stationarity, based on estimated autoregressive coefficients uniformly below unity. Nevertheless, their results are unfavorable to PPP; for they find "large and protracted real exchange rate fluctuations" and that "on average, the contribution of nominal exchange rate changes to the REER variance dominated that of relative price changes when the respective country was off gold" (Catão and Solomou, 2005, pp. 1265, 1266). Of course, the latter result does not apply to the United States and United Kingdom; for they (along with the other core countries, France and Germany) were on gold continuously from 1879.

Hasan (2004) examines PPP for silver-standard India. This study is distinctive in three respects, corresponding to the three tests of nonstationarity. First, fractional-integration modeling is applied. The value of the exponent parameter is estimated at below ½, and the hypothesis of a unit root in the real exchange rate is rejected. Second, a nonlinear model also results in rejection of a unit root. Third, Hasan is to be praised for testing also the hypothesis of stationarity against a nonstationarity alternative—a reversal of the usual null and alternative hypotheses. Stationarity cannot be rejected. Reversing the null and obtaining consistent results enhances confidence of stationarity- nonstationarity testing.

Evidence on PPP for classic metallic standards is mixed. Of the four studies surveyed, two have positive results and two negative.

5. World War I

Investigations of PPP for World War I are conveniently divided into Sweden and other countries. Sweden is the primary country, because Gustav Cassel, the greatest expositor and propagator of PPP, naturally tested the theory first for his own country. The PPP studies of Sweden during World War I are summarized in Table 7. Cassel's (1916) first test of the PPP theory pertained to Sweden in the early period of World War I. Sweden left the gold standard and adopted a floating exchange rate in February 1916, and Cassel refers to this event. However, the time period of this study ends in January 1916, and Sweden was on the gold standard throughout that period. The United Kingdom effectively went off gold in August 1914, largely via adoption of legal and extra-legal exchange (and gold) control. At the time, the only European country with a price index available to Cassel was the United Kingdom. Cassel uses the quantity theory of money to justify representing the Swedish price movement by the central-bank note issue. PPP theory is deemed to receive strong support: "The unmistakable conformity of the curves for the theoretical and actual rates may be regarded as a remarkably good proof of the theory here set forth" (Cassel, 1916, p. 64).

Table 7 Testing of PPP Theory, 1913-1919: Sweden						
Study	Time Period	Base Period	Specification[A]	Price Variable	Technique	Result
Cassel (1916)	1915-1916 (M)	1913	bivariate	banknotes (Sweden), WPI (UK)	comparative-static computation, table (e)	positive
Cassel (1918)	autumn 1918	"before the war"	bivariate	banknotes (Sweden), WPI (UK)	comparative-static computation, one observation (e)	negative
Heckscher (1930)	1914-1915 (Q), 1914-1917 (M)	July 1913 – June 1914	bivariate	WPI	comparative-static computation: table (e), graph (e)	negative

M = monthly, Q = quarterly
WPI = wholesale price index
e = equilibrium relationship tested directly
[A]Base country always United Kingdom.

In a later study, in which he coins the term "purchasing power parity," Cassel (1918) computes the Swedish currency overvalued with respect to PPP in autumn 1918. Heckscher (1930 finds that overvaluation applied to the entirety of 1914-1917. Cassel's explanation is Swedish restrictions on imports; while Heckscher emphasizes, rather, increased foreign demand for Swedish exports.

Table 8 shows PPP investigations during World War I for countries other than Sweden. Cassel (1916) shows that the PPP theory holds for France, Germany, and Russia—all on floating exchange rates—in December 1915, relative to Sweden. For all countries, he uses currency in circulation as a proxy for the price index. Later on, Cassel (1922, p. 182) would comment on this representation in early testing of his theory. Strictly speaking, use of the money stock (in whole or part) to play the role of a price index places the study below the bar for inclusion in the survey (see criterion 7 in section III.1). However, a true price index (presumably WPI or perhaps RPI) would be preferred by Cassel, as he comments in the above reference. Lack of availability of data is not Cassel's doing; so his studies in Table 7-8 are legitimately included in the survey. The same justification applies to inclusion of Keynes (1919) in Table 8.

The data situation is even worse for Cassel's (1919) examination of PPP for Germany. There are not even reliable data on currency in circulation, and Cassel must rely on conjecture for the German price index. Yet he detects "an enormous undervaluation of the mark as compared with the Swedish crown" (Cassel, 1919, p. 493). Reasons given are (1) the German government could obtain foreign exchange only from speculators abroad and at unfavorable exchange rates, and (2) capital was exported from the country, in anticipation of heavy taxation.

Table 8
Testing of PPP Theory, 1913-1919: Other Countries

Study	Time Period	Countries	Base Period	Base Country	Specification	Price Variable	Technique	Result
Cassel (1916)	1915 (M)	France, Germany, Russia	1913	Sweden	bivariate	banknotes	comparative-static computation, one observation (e)	positive
Cassel (1919)	1919 (M)	Germany	"prewar"	Sweden	bivariate	banknotes (Sweden), conjectural (Germany)	comparative-static computation, one observation (e)	negative
Keynes (1919)	1919 (M)	U.S., Spain, Japan, Switzerland, Denmark, Netherlands, Sweden, Norway, France, Italy, Germany	1913	United Kingdom	bivariate	currency	comparative-static computation, two observations (e)	positive (except Germany)
Bresciani-Turroni (1937)	1914-1918 (M)	Germany	1913	United States	univariate[A]	WPI	comparative-static computation, table (e)	positive

M = monthly
WPI = wholesale price index
e = equilibrium relationship tested directly
[A]Exchange rate: paper-mark price of gold mark

Keynes (1919) compares currency expansion with the exchange rate, for 11 countries versus the United Kingdom. A preceding comparison of currency expansion with price indexes (WPI and RPI) suggests that, as did Cassel, Keynes is testing the PPP via the quantity theory of money. In fact, Keynes (1919, p. 506) concludes: "The actual statistical relation between volume of currency, prices , and rates of exchange is in so close a conformity with the predictions of theory, as to surprise even theorists, having regard to the many disturbing factors of the present time. The only really anomalous case—that of Germany is dealt with by Professor Cassel in his article above."

So Keynes was an early supporter and follower of Cassel's PPP theory. Indeed, as editor of the *Economic Journal*, Keynes appended a note to Cassel (1916, p. 65), mentioning "Professor Cassel's interesting calculations." Later, Keynes would become a critic of PPP, stating: "the Purchasing Power Parity Theory of the Foreign Exchanges is not borne out by the recorded facts. I used to think this Theory more interesting than I think it now" (Keynes, 1930, p. 74).

Bresciani-Turroni (1937) shows that the anomalous case of Germany applies only to the postwar year, 1919, not to the war years, 1914-1918. "On the whole, it may be said that during the war period, save for temporary fluctuations, there was not much difference between the exchange rate of the mark and the 'price parities'" (Bresciani-Turroni, 1937,

p. 130). The base country is the United States, which in April 1917 went on a paper standard extralegally.

On balance, studies of PPP for the World War I period yield mixed findings. Because there is no attention to nonstationarity, all results must be viewed with caution.

6. floating rates—1920s

A tremendous number of PPP studies pertain to the 1920s, especially the first part of that decade. There are several reasons for this concentration. First, all countries on the classical gold standard left gold during World War, resulting in floating exchange rates. During the war, there was exchange-market intervention on the part of some countries, in particular, France and the United Kingdom. However, shortly after the end of the war, almost all exchange rates became freely floating, and remained so for a substantial part of the decade. PPP theory is typically of greater interest to researchers when exchange rates are floating rather than fixed. Second, the United States, which had effectively adopted a paper standard extralegally in April 1917, returned to gold in March 1922. The dollar thus provided an anchor to other countries for a return to a fixed-rate system and for assessing the level and volatility of the exchange rate while their currencies were floating. In particular, the United States is a natural base country for PPP computations. Third, even though World War I marked the end of the nominal international economic supremacy of the United Kingdom and even though that country did not readopt the gold standard until April 1925, its traditional importance as the center country of the classical gold standard make it a natural alternative base country for floating exchange rates of other countries. Fourth, the very fact that the once central country of a metallic standard and fixed-rate system (the gold standard) was now floating made the U.K. a most-interesting subject of PPP analysis, with the United States (the upstart other center country) as base country. Fifth, for researchers in the final quarter of the 20th century and beyond, it is natural to compare the floating rates of the post-Bretton Woods period with the floating rates of the 1920s, in particular, from the standpoint of PPP analysis.

The large number of studies requires systematic organization. First, separate tables pertain to investigations of individual countries: United Kingdom, France, Germany, Sweden, Switzerland, and Greece. Scholars' interest in the first four countries is understandable; for these countries are three of the gold-standard core countries and the home country of the modern "founder" of PPP theory. Switzerland and Greece each are the subject of more than one study—thus meriting a separate table—purely because of the predilection of researchers. Second, groups of studies of multiple countries naturally coalesce into separate tables: the U.S. as base country (subdivided into three groups of studies, with associated tables), the U.K. as base country, and "equal-status" countries (two tables: the U.S., U.K., France; then these three countries along with Germany). The term "equal status" denotes no unique or unambiguous base country when PPP between country pairs is investigated.

Consider first studies of the U.K. floating rate of 1919-1925, listed in Table 9. These investigations are all of the dollar-pound exchange rate. The interpretation here is that the countries are not co-equal in these studies; rather, the United States is the base country.

One may recall that in March 1922 the United States returned to the gold standard, a full three years before the United Kingdom did so.

Table 9
Testing of PPP Theory, 1920s: United Kingdom, Floating Rate

Study	Time Period	Specification[A]	Price Variable	Other Variables	Nonstationarity		Technique	Result
					Test	Other		
Cassel (1925a)	1919-1924 (M)	univariate[B]	WPI	capital movements			comparative-static computation, table (e), graph (e)	positive
Crump (1925)	1920-1924 (M)	univariate[B]	WPI	seasons (dichotomous)			comparative-static computation: table (e), graph (e)	mixed
Angell (1926)	1919-1924 (M)	bivariate[B]	WPI				comparative-static computation: table (e, c), graph (e, c)	mixed
Stolper (1948)	1919-1925 (M)	bivariate	WPI, RPI	unemployment (UK), employment (US)			graph (e)	mixed
Farag, Ott (1964)	1921-1925 (M)	bivariate	WPI	interest rates, industrial production, deviation from IRP		lagged change in exchange rate	regression (ec)	positive
Hodgson (1972)	1919-1925 (M)	trivariate	WPI	money stock; seasons, direct controls, "flight from pound" (dichotomous)		GLS with AR(1)	regression (ec)	positive
Myhrman (1976)	1920-1924 (M)	bivariate	WPI (U.K. only)			growth rates	graph (e)	positive
MacDonald (1985a)	1919-1925 (Q)	univariate, trivariate	WPI	seasons (dichotomous)	primitive test for unit root (crur)	logs, lagged exchange rate	regression (ec)	negative
Ahking (1990)	1921-1925 (M)	trivariate	WPI		ADF (mixed result)	logs	cointegration (e)	negative
Grilli, Kaminsky (1991)	1919-1925 (M)	univariate	WPI		PP, VR (crur)	logs		negative
Taylor (1992)	1921-1925 (M)	trivariate	WPI		ADF, PP (mixed result)	logs	cointegration (e)	positive
Michael, Nobay, Peel (1996)	1921-1925 (M)	biivariate	WPI	trends	ADF, PP, GH (crur)	logs	cointegration (e)	positive

M = monthly, Q = quarterly
WPI = wholesale price index, RPI = retail price index
IRP = interest-rate parity

GLS = generalized least-squares, AR(1) = first-order autoregression
ADF = augmented Dickey-Fuller, PP = Phillips-Perron, VR = variance-ratio, GH = Granger-Hallman
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship,
c = causal relationship tested
crur = cannot reject unit root
[A]Base country always United States.
[B]Base period 1913.

Once again, Cassel (1925a) is the lead researcher in the group. He uses semi-annual data on new foreign loans made by the United States to make the point that "the deviations from the purchasing-power parity shown by the real rates of exchange are chiefly due to international movements of capital" (Cassel, 1925a, p. 20). More fundamentally, he writes: "The conclusion is clear: *the best figures available…show that for the two leading currencies of the world the purchasing-power parity solely determines the normal position of the rate of exchange*" (Cassel, 1925a, p. 17, italics in original). Cassel (1925c, p. 151) views this finding as "the final proof of the validity of the theory of the purchasing power parities." In particular, Cassel states that "there is no room left for all the popular explanations of the variations in the rates of exchange, and especially the effect of the balance of trade." In a refutation of Cassel's position, Crump (1925) uses three different sets of price data to show that the dollar-pound real exchange rate follows a seasonal pattern related to the balance of trade.

Angell (1926, p. 430) finds that PPP holds as an equilibrium relationship but—because the exchange rate generally moved before the price variable—not as a causal relationship. He writes: "the general paths of the price parities and the exchanges are similar," and "the weight of the evidence suggests more clearly that the exchanges governed prices than it does the reverse." Stolper (1948) observes noticeable deviations of the exchange rate from PPP, largely explainable (he asserts) by differences in timing of the business cycle in the two countries. The latter conclusion should be tentative, because proxies of the cycle are imperfect representations of GDP (see Table 9). Interestingly, RPI parities work better than WPI parities.

Farag and Ott (1964) obtain positive results from an augmented-PPP analysis; but the (admittedly inadvertent) poor attention to nonstationarity (better to have applied the lagged exchange rate in level rather than first-difference form) and the possibility of spurious regression make their findings suspect. In contrast, Hodgson (1972), also with an augmented-PPP model, deserves praise for GLS estimation, thus overcoming spurious regression. Income proxy variables are dropped, as imperfect measures and collinear with price variables. Results are seen as highly favorable to PPP: "The study concludes that the exchange rate closely followed a path predicted by the 'fundamental' determinants….The findings also suggest that price levels were the most significant of the 'fundamental' determinants" (Hodgson, 1972, p. 250).

Myhrman (1976, p. 191) notices "striking similarity in the movements of the money supply, prices, and exchange rates." There are two major deviations, one explainable by U.S. monetary policy, the other unexplained. Omission of the U.S. price index detracts from comparability with the other studies; but transformation of series to growth rates acts to correct for spurious correlation.

The remaining authors all devote attention to nonstationarity. MacDonald's (1985a) test for a unit root is univariate, while his regression analysis is trivariate. He summarizes: "our results convincingly rejected PPP for the pound-dollar exchange rate over the period 1919 to 1925" (MacDonald, 1985a, p. 384). In a trivariate analysis, Ahking (1990) concludes that there is no cointegration involved, so long-run PPP does not hold. Grilli and Kaminsky (1991) cannot reject a unit root in the real exchange rate—the same result as for the gold standard, and again negative for the PPP theory.

In contrast, both Taylor (1992) and Michael, Nobay, Peel (1996) find that cointegration does exist, positive for long-run PPP. The latter authors present an exchange-rate error-correction equation that (1) includes a time-varying parameter for relative price (PPP) within the cointegration vector, and (2) contains deterministic trends also outside the cointegration vector. This model yields a result very pleasing to PPP: "The coefficient on the cointegration residual is highly significant with a point value close to unity, suggesting that adjustment to PPP is rapid when allowance is made for the influence of deterministic trends" (Michael, Nobay, and Peel, 1996, p. 359).

In sum, while there is no consensus among the authors, the preponderance of the evidence does suggest that the pound sterling in the 1920s floated in the dollar-pound exchange market in a manner consistent with the PPP theory.

In March 1919 France ended the exchange-market intervention that had effectively pegged the exchange rate, in favor of a freely floating franc. While its currency floated, France experienced substantial inflation but (unlike Germany) not hyperinflation. In December 1926 France returned to de facto stabilization of the exchange rate, and in June 1928 legalized the fixed rate by returning to the gold standard. Unlike the United States and United Kingdom, which reestablished the prewar gold par for their currencies, France devalued the franc to about $1/5^{th}$ of its prewar gold value, and therefore of its mint parity (exchange value) versus the dollar and the pound. The extent of the undervaluation of the franc, and of the overvaluation of the pound, is examined via PPP analysis in section V.2. Implications of the floating franc for the validity of the PPP theory are considered here, with Table 10 exhibiting PPP investigations of the floating franc.

Table 10
Testing of PPP Theory, 1920s: France, Floating Rate

Study	Time Period	Specification	Price Variable	Other Variables	Nonstationarity		Technique	Result
					Test	Other		
Angell (1926)	1919-1924 (M)	bivariate[A,B]	WPI				comparative-static computation, graph (e, c)	mixed
Dulles (1929)	1919-1927 , (M)	bivariate[A,C]	WPI				comparative-static computation, graph (e)	negative
Rogers (1929)	1919-1927 (M)	bivariate[A]	WPI (France only)				graph, correlation coefficient (e, c)	positive

Table 10
Testing of PPP Theory, 1920s: France, Floating Rate

Study	Time Period	Specification	Price Variable	Other Variables	Nonstationarity		Technique	Result
					Test	Other		
Wasserman (1936)	1919-1926 (M)	bivariate[A,D]	WPI				comparative-static computation: table (e), graph (e)	negative
Farag and Ott (1964)	1921-1926 (M)	bivariate[A]	WPI	interest rates, industrial production, forward premium			regression (ec)	positive
Aliber (1970)	1923-1926 (M)	bivariate[A]	RPI (France only)			percentage changes	computation for two intervals	negative
Pippenger (1973)	1923-1926 (M)	bivariate[A]	RPI, WPI (France only)			percentage changes	computation for two intervals	positive
Myhrman (1976)	1920-1923 (M)	bivariate[A]	WPI (France only)			growth rates	graph (e)	negative
Sicsic (1992)	1919-1926 (M)	bivariate[E]	WPI, RPI (France only)	money stock		growth rates	Granger causality (c)	negative

M = monthly
WPI = wholesale price index, RPI = retail price index
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship,
c = causal relationship tested
[A]Base country United States.
[B]Base period 1913.
[C]Base period 1914.
[D]Base period July 1914.
[E]Base country United Kingdom.

Angell (1926, p. 437) observes that PPP holds as an equilibrium relationship but not as a causal relationship: "When the exchanges are compared with the price *parities*, the principal movements tend rather to coincide" [italics in original]. With the exchange rate graphed with the French price index alone, price leads the exchange, indicative of causal PPP. This result illustrates the pitfalls of using the domestic price index alone as the price variable in PPP investigations.

A strongly negative judgment regarding the validity of PPP theory is made by Dulles (1929, p. 24), who notes "the wide divergence of purchasing power parities from actual parities." She does suggest that the RPI might yield more favorable results than the WPI. She deserves credit for the prophetic statement that "there is no sure ground for prophecy and policy in the purchasing power parity theory until statistical science applied to economic data has been further developed." Her statement is, of course, applicable to the correlation analysis of Rogers (1929), who alternatively leads and lags price versus the exchange rate. The positive findings could be spurious. Also, as mentioned above, use of the domestic price index alone rather than its ratio to the foreign price index (that is, PPP) could lead to misleading results from the standpoint of PPP theory. Rogers (1929, p. 97) does deserve credit for noticing the greater flexibility of the exchange rate relative to commodity prices; he observes that "naturally the movements of exchange…were much sharper and of greater range than those of prices."

Wasserman's (1936) variables are, alternatively, (1) the dollar-denominated French price index versus the U.S. price index, and (2) the franc-denominated U.S. price index versus the French price index—the latter formulation is unusual for bivariate analysis, but within the scope of PPP theory (see section I.3). The negative result is explained in terms of the pricing policy of French firms and the behavior of French wages.

Farag and Ott (1964, p. 96) again put their augmented PPP model to work, and, as for the other experiences, conclude that PPP is vindicated: "The results clearly indicated that (lagged) relative prices were significant in explaining movements in the exchange rate in France during this period." However, the possibility of spurious regression or correlation is present in this study and all the others thus far listed in Table 10.

In taking percentage changes of variables, Aliber (1970) and Pippenger (1973) guard against this spuriousness. Using superior data and methodology, Pippenger redoes Aliber's computation and turns Aliber's negative finding for PPP into a positive finding: "relative changes in exchange rates and price levels were of roughly the same order of magnitude" (Pippenger, 1973, p. 614). Myhrman (1976) transforms variables to growth rates, which could be percentage changes (he does not specify the calculation algorithm). Myhrman (1976, p. 192) concludes that "the purchasing power relationship between prices and the exchange rate [is] much looser in France [than in Britain]."

In a Granger-causality analysis, Sisic (1992) cannot reject that the exchange rate Granger-causes the WPI, but rejects that the WPI Granger-causes the exchange rate. He states: "The causality tests show that the exchange rate was driving the wholesale price indexes and that there was no feedback" (Sisic, 1992, p. 85). He does not comment on the result that Granger causality of the exchange rate on the RPI and of the RPI on the exchange rate are both rejected. All these results are evidence against PPP as a causal relationship, with the caveat that the foreign price variable is omitted from the model.

In sum, studies of the 1920s French floating-rate experience have quite divergent implications regarding the validity of PPP, and no general assessment can be made.

PPP studies of the German mark in the 1920s are shown in Table 11. At the end of July 1914, Germany abandoned the gold standard and a floating exchange rate resulted. Inflation resulted, then hyperinflation in the second half of 1923, until a currency reform in November 1923. Germany formally readopted the gold standard, with a new currency, in August 1924.

Table 11 Testing of PPP Theory, 1920s: Germany, Floating Rate								
Study	Time Period	Specification[A]	Price Variable	Other Variables	Nonstationarity		Technique	Result
					Test	Other		
Bresciani-Turroni (1937)	1919-1923 (M)	univariate[B,C]	WPI				comparative-static computation, table (e, c), graph (e, c)	negative
	1923 (D)	univariate[B,C]	WPI				comparative-static computation, table (e)	mixed
Rogers (1929)	1918-1923 (M)	bivariate	WPI			logs, deviations from compound-interest trends	graph, correlation coefficient (e, c)	positive
Haberler (1936)	1919-1926 (M)	univariate[B]	WPI			logs	comparative-static computation, graph (e)	negative
Frenkel (1976)	1920-1923 (M)	bivariate	WPI, RPI (Germany only)			logs, percentage changes, GLS with AR(1)	graph (e), regression (ec)	positive
Bernholz, Gärtner, Heri (1985)	1914-1923 (M)	univariate[D]	WPI				computation of maximum, period-end real exchange rate (e)	mixed

D = daily, M = monthly
WPI = wholesale price index, RPI = retail price index
GLS = generalized least-squares, AR(1) = first-order autoregression
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship, c = causal relationship tested
[A]Base country always United States.
[B]Base period 1913.
[C]Exchange rate: paper-mark price of gold mark.
[D]Base period 1914.

Bresciani-Turroni (1937) finds an undervaluation of the mark in the foreign-exchange market compared to the relative internal value (PPP). This is a general result that other researchers also were to observe. Only for certain subperiods does the movement of PPP precede that of the exchange rate. Haberler (1936, p. 62) observes an undervaluation of the mark even after stabilization, and concludes that it was “probable that there were not only temporary but also permanent changes of [the real exchange rate].”

Rogers (1929) transforms the series, so that a spurious relationship can be overcome. An equilibrium PPP relationship results. The lagged relationship between the series (from which the direction of causation could be inferred) changes over time, eventually becoming non-discernible. Bernholz, Gärtner, and Heri (1985) obtain their usual result of PPP holding in the long run but not in the short run.

The same remark as to the divergent results of the studies applies to the German as to the French experience of the 1920s.

Table 12 summarizes PPP investigations involving 1920s Sweden. That country returned to the gold standard in April 1924. Therefore the studies of Cassel (1925a, 1925b), given their time periods, pertain to a fixed rate for Sweden, in part and whole, respectively. However, Denmark and Norway did not stabilize their exchange rates until 1926 and 1928. So Cassel (1925b) may be viewed as a study of floating-rate Denmark and Norway, with gold-standard Sweden as the base country.

The most interesting feature of Table 12 is the almost uniformly negative results regarding PPP. Only in Cassel (1925a), and only for the subperiod 1922-1924, is there a positive finding. Cassel uses capital flows to help explain the 1921-1922 overvaluation, and the 1923-1924 undervaluation, of the Swedish currency.

Table 12
Testing of PPP Theory, 1920s: Sweden, Floating and Fixed Rate

Study	Time Period	Base Period	Base Country	Specification[A]	Nonstationarity		Technique	Result
					Test	Other		
Anonymous (1921)	1920-1921 (Q)	1913	U.K.	bivariate			comparative-static computation, table (e)	negative
Flux (1924)	1920-1923 (M)	1913	Denmark	univariate		logs	comparative-static computation, graph (e, c)	negative
Cassel (1925a)	1920-1924 (A)	1913	U.S.	bivariate			comparative-static computation, table (e)	mixed
Cassel (1925b)	1925 (M)	January 1925	Denmark, Norway	bivariate			comparative-static computation, one observation, table (e)	negative

M = monthly, Q = quarterly, A = annual
e = equilibrium relationship tested directly, c = causal relationship tested
[A]Price variable always WPI (wholesale price index).

Switzerland stabilized the exchange rate of its currency versus the dollar in October 1924, and returned to the gold standard in the following year. As a country of low inflation, in contrast to France and Germany, the Swiss 1920s experience deserves consideration. Two studies of the experience are listed in Table 13, and the authors pay attention to nonstationarity. Results regarding PPP are mixed. For Junge (1984), findings are negative for three out of four base countries. For Bleaney (1998), there is cointegration of the exchange rate and PPP for France or Germany as base country, but not for the United States or United Kingdom in that role. The latter two countries, together with Switzerland, can be classified as low-inflation in the 1920s. So Bleaney (1998, p. 241) concludes that “for exchange rates between relatively low-inflation currencies, exchange rate behavior tended not to be consistent with long-run PPP.”

Table 13
Testing of PPP Theory, 1920s: Switzerland, Floating Rate

Study	Time Period	Specification[A]	Base Countries	Nonstationarity		Technique	Result
				Test	Other		
Junge (1984)	1921-1925 (M)	bivariate	France, Germany, U.S., U.K.		logs, Δlogs; GLS with AR(1)	regression (ec)	negative, except for Germany
Bleaney (1998)	1921-1924 (M)	bivariate	France, Germany, U.S., U.K.	ADF (mixed result)	logs	cointegration (ec)	mixed

M = monthly
GLS = generalized least-squares, AR(1) = first-order autoregression, ADF = augmented Dickey-Fuller
ec = equilibrium relationship tested via imposed causal relationship
[A]Price variable always WPI (wholesale price index).

Unlike Switzerland, Greece was a high-inflation country in the 1920s. Greece moved from a fixed exchange rate to a freely floating rate in September 1922. It did not stabilize the rate again until 1927, and it returned to the gold standard one year later. Studies of the Greek floating-rate experience are shown in Table 14. Just as for Switzerland, there are multiple alternative base countries, the same for each study. All three studies employ modern time-series analysis, and all are favorable to PPP. Phylaktis (1992, p. 510) concludes: “Bearing in mind that the rate of inflation in Greece was high and variable during that period, our results lend support to the view that PPP is likely to hold when country pairs experience large differentials in price movements.” That generalization does not apply to Germany versus the United States (Table 11).

Table 14
Testing of PPP Theory, 1920s: Greece, Floating Rate

Study	Time Period	Specification[A]	Base Countries	Nonstationarity		Technique	Result
				Test	Other		
Phylaktis (1990)	1923-1925 (M)	bivariate, trivariate	U.K., U.S., France		logs	general-to-specific modeling, error-correction model (ec)	positive
Phylaktis (1992)	1923-1925 (M)	univariate, bivariate	U.K., U.S., France	ADF: univariate (crur), bivariate (rur)	logs	cointegration (e)	positive
Georgoutsos, Kouretas (1992)	1923-1925 (M)	trivariate	U.K., U.S., France	ADF, PP (crur)	logs	cointegration (e)	positive

M = monthly
ADF = augmented Dickey-Fuller, PP = Phillips-Perron
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship
crur = cannot reject unit root, rur = reject unit root
[A]Price variable always WPI (wholesale price index).

An impressive, two-volume, assemblage of studies of the post-World-War I monetary and exchange-rate experience of European countries is Young (1925). Papers were contributed by a large number of government officials and academic economists, including Gustav Cassel, John Maynard Keynes, Joseph Schumpeter, and Hjalmar Schacht. Many of the writers in effect test the PPP approach to the exchange rate, but unfortunately these four persons are not among them. There is a set of excellent statistical tables at the end of each volume; economic historians have found the data series in these tables to be extremely useful.

Table 15
Testing of PPP Theory, 1920s: Young Volumes, U.S. Base Country

Study	Country	Time Period	Specification[A]	Exchange-Rate Variable	Technique	Result
Wight (1925a)	Austria	1923-1925 (M)	univariate, bivariate	cents per krone	comparative-static computation: graph, table (e)	mixed
Wight (1925b)	Belgium	1921-1925 (M)	univariate, bivariate	cents per franc	comparative-static computation: graph, table (e)	mixed
Young (1925b)	Czecho-slovakia	1922-1925 (M)	univariate, bivariate	cents per crown	comparative-static computation: graph, table (e)	mixed
Wood (1925a)	Denmark	1920-1925 (M)	univariate, bivariate	cents per krone	comparative-static computation: graph, table (e)	mixed
Young (1925c)	France	1914-1924 (M)	univariate, bivariate	cents per franc	comparative-static computation: graph, table (e)	mixed
Young (1925d)	Hungary	1921-1925 (M)	univariate, bivariate	cents per krone	comparative-static computation: graph, table (e)	mixed
Bachi (1925)	Italy	1921-1924 (M)	bivariate	percent of parity	comparative-static computation, table (e)	negative
Jacobson, Jaeger, Young (1925)	Italy	1917-1924 (M)	univariate, bivariate	cents per lira	comparative-static computation: graph, table (e)	mixed
Wight (1925c)	Netherlands	1920-1925 (M)	univariate, bivariate	cents per guilder	comparative-static computation: graph, table (e)	mixed
Wood (1925b)	Norway	1920-1925 (M)	univariate, bivariate	cents per krone	comparative-static computation: graph, table (e)	mixed
Young (1925e)	Poland	1921-1925 (M)	univariate, bivariate	cents per mark,[B] zloty	comparative-static computation: graph, table (e)	mixed
Jacobson, Jaeger (1925)	Germany	1914-1924 (M)	univariate, bivariate	cents per mark, reichsmark	comparative-static computation: graph, table (e, c)	negative
Jacobson (1925)	Russia	1916-1925 (M)	univariate, bivariate	cents per ruble	comparative-static computation: graph, table (e)	negative
Young (1925f)	Spain	1921-1925 (M)	univariate, bivariate	cents per peseta	comparative-static computation: graph, table (e)	mixed

Table 15 Testing of PPP Theory, 1920s: Young Volumes, U.S. Base Country						
Study	Country	Time Period	Specification[A]	Exchange-Rate Variable	Technique	Result
Wood (1925c)	Sweden	1919-1925 (M)	univariate, bivariate	cents per krona	comparative-static computation: graph, table (e)	mixed
Wood (1925d)	Switzerland	1921-1925 (M)	univariate, bivariate	cents per franc	comparative-static computation: graph, table (e)	mixed
Young (1925g)	United Kingdom	1912-1924 (M)	univariate, bivariate	dollars per pound	comparative-static computation: graph, table (e)	mixed

M = monthly
e = equilibrium relationship tested directly, c = causal relationship tested
[A]Base period always 1913. Price variable always WPI (wholesale price index).
[B]Par of German gold mark used for PPP computation.

Almost all the authors adopt a common computation methodology, plotting and tabulating the exchange rate versus the PPP, with the United States as the base country. These studies are summarized in Table 15. The following general findings can be discerned.

1. The exchange rate and PPP move more or less in correspondence.
2. There is persistent directional deviation of one of these variables from the other.
3. The usual pattern is that the domestic currency depreciated more than indicated by PPP, that is, the currency is undervalued in the foreign-exchange market.
4. There is closer correspondence of the exchange rate and PPP in recent years than previously, especially if exchange-rate stabilization has occurred.

For enhanced understanding of Table 15, it is useful to know when the various countries stabilized the exchange rate. This stabilization, achieved via exchange-market intervention, was usually a step to rejoining the gold standard, the hallmark of which is currency convertibility into gold (in some cases, gold coin; in other cases, only gold bars). Austria stabilized the exchange rate in 1922 and went on the gold standard a year later. Belgium did both in 1926. Czechosolovakia stabilized in early 1923. Hungary stabilized and went on gold in 1925. Italy stabilized in 1927, returned to gold in 1928. Netherlands returned to the gold standard on the same date as the United Kingdom in 1925; Norway returned to the gold standard in 1928. Poland stabilized with a new currency in 1924. Experiences of remaining countries in the table were outlined above.

Table 16 presents Bernholz, Gärtner, and Heri's (1985) applications of their model to the 1920s. The usual results (PPP violated in short run, validated in long run) pertain to Hungary and Poland. Austria is an outlying case, with PPP not holding in the long run. BGH suggest base-period selection and inflation as possible explanations.

Table 16 Testing of PPP Theory, 1920s: Bernholz, Gärtner, Heri Study; U.S. Base Country							
Study	Country	Time Period	Base Period	Specification[A]	Price Variable	Technique	Results
Bernholz, Gärtner, Heri (1985)	Austria	1914-1924 (M)	1914	univariate	RPI	computation of maximum, period-end real exchange rate (e)	negative
	Hungary	1914-1925 (M)	1914		RPI, WPI		mixed
	Poland	1919-1924 (M)	January 1921		WPI, RPI		mixed

M = monthly
WPI = wholesale price index, RPI = retail price index
e = equilibrium relationship tested directly
[A]Base country always United States.

Studies testing PPP in the 1920s for multiple domestic countries with the United States as base country are shown in Table 17. They fit chronologically into two groups: those that ignore nonstationarity, and those that address the issue (even if via another route). The first group covers Furniss (1922) through Aliber (1962), with the possible exception of Flux (1924).

Furniss (1922, p. 56) is distinguished by the author's price index numbers "constructed from the same group of commodities in each country." He observes "the tendency of the exchange rates to conform to the purchasing power parities of the different national moneys" (Furniss, 1922, p. 58). Similarly, Robertson (1922, p. 141) notes "the general normal relation between price-levels and exchanges." Among the countries that he examines is Canada, which stabilized its exchange rate in 1925 and rejoined the gold standard in 1926, and Japan, which did not return to the gold standard until 1930. Germany exemplifies "abnormal cases" (Robertson, 1922, p. 141). An outlying, negative, finding for 1920s Germany is common to many studies.

Table 17 Testing of PPP Theory, 1920s: Multiple Domestic Countries, U.S. Base Country									
Study	Countries	Time Period	Specification	Price Variable	Other Variables	Nonstationarity		Technique	Results
						Test	Others		
Furniss (1922)	France, Germany, Italy, U.K.	1919-1921 (M)	bivariate[A]	WPI				comparative-static computation, graph (e)[B]	positive
Robertson (1922)	France, Italy, U.K., Sweden, Canada, Japan, Germany, Netherlands, Norway	1920 (M)	bivariate[H]	WPI, RPI				comparative-static computation, one observation	positive, except for Germany

Table 17 Testing of PPP Theory, 1920s: Multiple Domestic Countries, U.S. Base Country									
Study	Countries	Time Period	Specification	Price Variable	Other Variables	Nonstationarity		Technique	Results
						Test	Others		
U.S. Tariff Commission (1922)	U.K., France, Germany[C]	1919-1921 (M)	univariate[A]	WPI				comparative-static computation: graph, table (e)	mixed, except negative for Germany
Keynes (1923)	U.K., France, Italy	1919-1923 (M)	bivariate[A]	WPI				comparative-static computation: graph, table (e)	positive
Flux (1924)	Sweden, France, U.K., Italy	1920-1923 (M)	univariate[A]	WPI			logs	comparative-static computation, graph (e, c)	negative
Gregory (1925)	France, Italy, U.K., Sweden, Canada, Japan	1919-1920 (D)	bivariate[D]	WPI				comparative-static computation, table (e)	negative
Graham (1930)	U.K., 11 European countries[E]	1919-1923 (M)	univariate[A]	WPI				comparative-static computation: graph, table (e)	positive, except for Germany
Lester (1939)	Denmark, Norway	1924-1928 (Q)	univariate[A]	WPI				comparative-static computation, table (e)	mixed
Tsiang (1959)	U.K., Norway, France	1919-1927 (M)	bivariate[A]	WPI				comparative-static computation, graph (e)	mixed
Aliber (1962)	U.K., France, Belgium, Netherlands, Switzerland	1919-1926 (M)	univariate[A]	WPI, RPI				comparative-static computation, graph (e)	mixed
Rogalski, Vinso (1977)	U.K., France, Italy, Japan, Norway, Sweden	1920-1924 (M)	bivariate	WPI			series filtered to white noise	cross-correlations (e, c)	positive, except for Sweden
Thomas (1973a)	France, Canada, Spain	1920-1924 (M)	bivariate	WPI	income proxies, interest rate		lagged exchange rate and price	regression (ec)	positive
Thomas (1973b)	U.K., Canada, Japan, nine European countries[F]	1920-1924 (M)	bivariate	WPI	income proxies, interest rate, trend, seasonals		lagged exchange rate and price	regression (ec)	positive
Hodgson and Phelps (1975)	Canada, Japan, U.K., 11 European countries[G]	1919-1925 (M)	bivariate	WPI, RPI			logs, lagged dependent variable	regression (ec), primitive Granger-like	positive

Table 17 Testing of PPP Theory, 1920s: Multiple Domestic Countries, U.S. Base Country									
Study	Countries	Time Period	Specification	Price Variable	Other Variables	Nonstationarity		Technique	Results
						Test	Others		
							(exchange rate or price)	causality (c)	
Krugman (1978)	Germany, U.K., France	1920-1926 (M)	univariate, bivariate	WPI			logs, GLS with AR(1)	statistics of real exchange rate, regression (IV)	mixed
Hakkio (1984)	U.K., France, Canada, Japan	1921-1925 (Q)	bivariate	WPI			logs, GLS with AR(1) and cross-correlated errors	regression (ec, IV)	mixed
De Grauwe, Janssens, Leliaert (1985)	U.K., France, Germany	1921-1926 (M)	univariate	WPI		spectral analysis (mixed result)	first-differences	correlation of real and nominal exchange rates	mixed

Q = quarterly, M = monthly, D = daily
WPI = wholesale price index, RPI = retail price index
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship,
c = causal relationship tested, IV = instrumental variables
GLS = generalized least-squares, AR(1) = first-order autoregression
[A]Base period 1913.
[B]Also, table with only one observation and three countries.
[C]Also Canada, Australia, Japan, Sweden, Italy—but conclusions not drawn for these countries.
[D]Base period March 31, 1919.
[E]Sweden, Switzerland, Spain, Norway, Netherlands, Czechoslovakia, Denmark, Belgium, France, Italy, Germany.
[F]France, Belgium, Denmark, Netherlands, Norway, Sweden, Spain, Italy, Switzerland.
[G]Germany, Austria, Switzerland, Finland, France, Belgium, Netherlands, Sweden, Italy, Norway, Spain.
[H]Base period 1913, except 1914 for Germany, Netherlands, and Norway.

United States Tariff Commission (1922) is a government publication that includes PPP and other country data, and which preceded Young (1925). Keynes (1923) is concerned with the impact of transport costs, tariffs, and nontraded goods on the validity of PPP theory. Yet he admits that "even under such abnormal conditions as have existed since the Armistice…the Purchasing Power Parity Theory, even in its crude form, has worked passably well" (Keynes, 1923, pp. 101, 106). Flux (1924) is distinguished by an early use of logarithms in PPP computation (via a logarithmic scale in graphing), while Gregory (1925) reprints data from a League of Nations publication. Both authors have negative findings.

In contrast, the results of Graham (1930, pp. 117, 121) show "in most cases a rather close correspondence between actual exchange rates and the theoretical pars based on relative prices….If we exclude Germany, the clustering round the 100% figure is marked and aberrations were apparently self corrective." Yeager (1976, p. 221) writes that Lester (1939) "found deviations of actual from calculated rates to be almost always within a few percent.” However, the present reviewer judges Lester’s result to be “mixed,” because Lester emphasizes, rather, the persistence of deviations in one direction or the other. Tsiang (1959) and Aliber (1962) use PPP to judge the stability of exchange-rate speculation.

Turning to studies that address nonstationarity, overall results are more positive than negative for PPP. Rogalski and Vinso (1977, p. 76) find: “For England, France, Japan, and Norway, the foreign exchange market reacts immediately, or nearly so, to changes in relative price levels as predicted by PPP.” Results are also positive for Italy, but ambiguous for Sweden. Thomas (1973a, 1973b) copes with spurious regression via lagged exchange rate and PPP, but only for non-augmented theory. His general result is that speculation was not a primary influence on the exchange rate; fundamental determinants (represented by the PPP) played that role. He writes: “It is clear (and was at the time) that price levels are crucially important in the determination of exchange rates” (Thomas, 1973b, pp. 178-179).

Hodgson and Phelps (1975) employ a primitive, Granger-like causation approach, reversing exchange rate and PPP to see if regressions have a better fit. They summarize their results as follows: “with the passage of a relatively short period of time, currency purchasing powers begin to exert a dominant influence on exchange rates and explain a remarkably high percentage of their variation” (Hodgson and Phelps, 1975, p. 63). Krugman (1978) accounts for the endogeneity of prices, via instrumental-variable estimation. He concludes: “there is more to exchange rates than PPP….the deviations from PPP are large, fairly persistent, and seem to be longer in countries with unstable monetary policies” (Krugman, 1978, p. 407).

Hakkio (1984) has a multivariate model, and allow errors to be cross-correlated across countries. PPP does not perform well, and Hakkio (1984, p. 275) states boldly that “PPP fails in the 1920s.” De Grauwe, Janssens, and Leliaert (1985) employ an unusual, and probably invalid, test for nonstationarity. Also, correlating first-differences of the nominal and real exchange rate, they find a high correlation for France. Although the authors draw no conclusion regarding PPP, this is a case against the theory.

Table 18 summarizes 1920s studies with the United Kingdom as base country. Interestingly both the earliest (Flux, 1924) and most-recent (Thomas, 1972) studies transform variables to logarithms—the sole concession to nonstationarity. The only positive results are those of Thomas (1972). Bachi (1925, p. 177) comments that “the ratio has constantly deviated from 100, showing considerable divergencies.” Gregory (1925) notices that countries with the greatest inflation have the largest deviations from PPP. He infers that expected inflation is the principal explanation of the divergences. Copland (1930, p. 78) shows that, for Australia, “exchanges did not fluctuate according to purchasing power parity.” Thomas (1972), however, rejects destabilizing speculation—as distinct from PPP—for eight of ten countries. The exceptions are France (which result is consistent with other studies) and Norway.

Table 18 Testing of PPP Theory, 1920s: Multiple and Other Countries, U.K. Base Country								
Study	Countries	Time Period	Specification[A]	Other Variables[B]	Nonstationarity		Technique	Results
					Test	Others		
Flux (1924)	U.S., Japan, France, Netherlands,	1920-1923 (M)	univariate[A]			logs	comparative-static computation, graph (e, c)	negative
Katzenellenbaum (1925)	Russia	1922-1923 (M)	univariate[C]				comparative-static computation, table (e)	negative
Bachi (1925)	Italy	1914-1924 (M)	univariate[D]				comparative-static computation, table (e)	negative
Gregory (1925)	U.S., Italy, France, Sweden	1920 (M)	bivariate[C]				comparative-static computation, table (e)	mixed
Copland (1930)	Australia	1920-1921 (M)	bivariate[C]				comparative-static computation, table (e)	negative
Thomas (1972)	U.S., France, Netherlands, Sweden	1920-1924 (M)	bivariate	income proxies, interest rate			regression (ec)	positive
	U.S., Japan, India, 7 European countries[E]	"early 1920s" (M)	bivariate			logs	regression (ec)	positive

M = monthly
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship,
c = causal relationship tested
[A]Price index always WPI (wholesale price index).
[B]In addition to price.
[c]Base period 1913.
[D]Base period 1901-1905.
[E]Norway, France, Belgium, Netherlands, Italy, Sweden, Switzerland.

Tables 19 and 20 deal with 1920s studies which do not have a base country as such. A set of "equal status" countries is selected, and PPP between pairs of these countries is investigated. In principle, all possible combinations of countries is considered; but this is not always the case in practice. In Table 19 the country group consists of the United States, United Kingdom and France. In Table 20 Germany is added to the group. In both tables all studies are conducted using modern time-series analysis, with explicit attention paid to nonstationarity.

Considering first Table 19, Frenkel (1978) finds that PPP is satisfied as an equilibrium relationship but fails as a causal relationship (although specific results are not reported). In all cases, one cannot reject the hypothesis that PPP does not Granger-cause the exchange rate. In most cases, one can reject the hypothesis that the exchange rate does not Granger-cause prices. Edison (1985) also has mixed results. He concludes: "PPP does not hold for two of the three exchange rates examined" (Edison, 1985, p. 370). MacDonald (1985b) shows that there is no mean reversion of the real exchange rate for two of the three country pairs examined, but only one of the two is common with Edison. Georgoutsos and Kouretas (2000) have the only uniformly positive results for PPP.

Table 19
Testing of PPP Theory, 1920s, Equal-Status Countries: U.S., U.K., France

Study	Country Pairs	Time Period	Specification[A]	Nonstationarity		Technique	Result
				Test	Other		
Frenkel (1978)	U.S.-U.K. U.S.-France U.K.-France	1921-1925 (M)	bivariate		logs, Δlogs, lagged exchange rate, GLS with AR(1)	regression (ec), Granger causality (c)	mixed
Edison (1985)		1921-1925 (M)	trivariate, bivariate		logs, Δlogs, lagged exchange rate and price, GLS with AR(1)	general-to-specific modeling: regression (ec)	mixed
MacDonald (1985b)		1921-1925 (M)	univariate	Box-Jenkins	logs		mixed
Georgoutsos, Kouretas (2000)		1921-1926 (M)	trivariate	ADF, PP (crur)	logs	cointegration (e)	positive

M = monthly
ADF = augmented Dickey-Fuller, PP = Phillips-Perron
GLS = generalized least-squares, AR(1) = first-order autoregression
crur = cannot reject unit root
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship,
c = causal relationship tested
[A] Price variable always WPI (wholesale price index).

Table 20
Testing of PPP Theory, 1920s, Equal-Status Countries: U.S., U.K., France, Germany

Study	Country Pairs	Time Period	Specification	Price Variable	Nonstationarity		Technique	Result
					Test	Other		
Frenkel (1980)	GER-U.K. FRA-U.K. U.S.-U.K. FRA-U.S.	1921-1925 (M)	bivariate, trivariate	WPI, RPI		logs, GLS with AR(1)	regression (2SLS)	positive
Taylor, McMahon (1988)	GER-U.K. FRA-U.K. U.S.-U.K. FRA-U.S. GER-U.S. GER-FRA		bivariate	WPI	ADF, PP (crur)	logs	cointegration (ec)	positive
Ardeni, Lubian (1989)			trivariate	WPI	ADF (crur)	logs	cointegration (e)	negative
Michael, Nobay, Peel (1997)			univariate	WPI	ADF, PP, GH (crur)	logs	ESTSAR (e)	positive

M = monthly
WPI = wholesale price index, RPI = cost-of-living index

GER = Germany, FRA = France
ADF = augmented Dickey-Fuller, PP = Phillips-Perron, VR = variance-ratio, GH = Granger-Hallman
GLS = generalized least-squares, AR(1) = first-order autoregression
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship
crur = cannot reject unit root
2SLS = two-stage least-squares
ESTSAR = exponential smooth-transition autoregression

Turning to Table 20, the studies are more pleasing to PPP, with all but one positive. Frenkel (1980, p. 241) concludes that "the PPP doctrine held up reasonably well during the 1920's." Also, for Taylor and McMahon (1988, p. 402), "the results are strongly supportive of long-run PPP." Ardeni and Lubian (1989) exhibit the only negative findings. For country pairs with Germany, cointegration is not applicable; because German exchange rate and price are found to be I(2) rather than I(1). For the other country pairs, the hypothesis of non-cointegration cannot be rejected. The authors conclude that "PPP during the twenties did not perform as well as commonly believed" (Ardeni and Lubian, 1989, p. 361).

Very impressive is the study of Michael, Nobay, and Peel (1997). These authors specify a nonlinear adjustment process: "the larger the deviation from PPP, the stronger the tendency to move back to equilibrium….for small deviations, y_t [the stationary error term representing the deviations from PPP] may follow a unit root or even explosive behavior, but for large deviations the process is mean-reverting" (Michael, Nobay, and Peel, 1997, p. 866). Again, German price and nominal exchange rates are I(2) versus I(1) for variables of the other countries. The authors proceed with the three non-German pairs: U.S./U.K., U.S./France, U.K./France. They find "random walk behavior for small deviations…but fast adjustment for large (positive or negative) deviations from PPP". They conclude: "Despite the high degree of persistence in PPP deviations, our framework provides strong evidence of mean-reverting behavior for the real exchange rate" (Michael, Nobay, and Peel, 1997, pp. 876, 877).

7. 1930s

In September 1931 the United Kingdom abandoned the gold standard for a managed float, while the United States did not leave gold until March 1933. Table 21 lists PPP testing for the United Kingdom during the 1930s, with the United States as base country. Overall, results are negative. Whitaker and Hudgins (1977) pay explicit attention to exchange-market intervention, via a dichotomous variable. Although PPP is not discussed as such, the study is in the augmented-PPP tradition. The coefficient of the PPP variable is not significant. Broadberry (1987, p. 74) finds that "in the long run the exchange rate and relative wholesale prices moved in line." The relationship changed after the United States left gold, and Broadberry shows that exchange-market intervention cannot account for that break. Grilli and Kaminsky (1991) cannot reject a random walk in the real exchange rate.

Table 21 Testing of PPP Theory, 1930s: United Kingdom							
Study	Time Period	Specification[A]	Other Variables	Nonstationarity		Technique	Result
				Test	Other		
Whitaker, Hudgins (1977)	1931-1938 (M)	bivariate	income proxy, interest rate; official support for sterling, U.S. departure from gold standard (dichotomous)		GLS with AR(1), lagged exchange rate	regression (ec)	negative
Broadberry (1987)	1931-1939 (Q)	bivariate	money stock, industrial production, interest rate, U.K. gold reserves, seasonals		Δlogs	regression (ec)	mixed
Grilli and Kaminsky (1991)	1931-1939 (M)	univariate		PP, VR (crur)	logs		negative

M = monthly, Q = quarterly
PP = Phillips-Perron, VR = variance-ratio
GLS = generalized least-squares, AR(1) = first-order autoregression
ec = equilibrium relationship tested via imposed causal relationship,
crur = cannot reject unit root
[A] Price variable always WPI (wholesale price index). Base country always United States.

The authors in Table 22 deal with the 1930s PPP experience of multiple countries. Overall, again results are not generally positive. Graham (1935, p. 163) states that "the world integration of prices…is, for the time being at least, non-existent." He compares (1) the percent devaluation of the domestic currency with respect to gold, and (2) the domestic price index expressed in gold. Evidence of PPP is negative for the gold bloc (France, Belgium, Italy, Netherlands, Switzerland, Poland) and other fixed-rate countries (Germany, Austria, Czechoslovakia), mixed for countries with 40-50-percent devaluation (United States, United Kingdom, Dominions, and others), and positive only for countries with 33 1/3 percent devaluation (Argentina, Japan). One may comment that PPP theory would be better tested as country pairs rather than each country individually against gold.

Table 22 Testing of PPP Theory, 1930s: Multiple Countries									
Study	Countries	Time Period	Specification	Exchange Rate	Price Variable	Nonstationarity		Technique	Result
						Test	Other		
Graham (1935)	U.S., Canada, U.K., N.Z., Australia, Argentina, 11 European[A] 3 Asian,[B]	1934 (M)	bivariate[C]	gold price	WPI (domestic only)			comparative-static, computation, table (e)	mixed

Table 22 Testing of PPP Theory, 1930s: Multiple Countries									
Study	Countries	Time Period	Specification	Exchange Rate	Price Variable	Nonstationarity		Technique	Result
						Test	Other		
White (1935)	U.K. Sweden, Argentina	1930-1933 (M)	bivariate[D]	U.S. dollars per domestic currency	WPI (domestic only)			table (c)	negative
Broadberry, Taylor (1992)	GER-U.K. FRA-U.K. U.S.-U.K. FRA-U.S. GER-U.S. GER-FRA	1930-1939 (M)	univariate, bivariate		WPI	ADF (mixed)	logs	cointegration (e), Granger causality (c)	mixed

M = monthly
WPI = wholesale price index
ADF = augmented Dickey-Fuller
GER = Germany, FRA = France
e = equilibrium relationship tested directly, c = causal relationship tested
[A]Germany, Austria, Switzerland, Czechoslovakia, France, Poland, Belgium, Italy, Netherlands, Sweden, Yugoslavia.
[B]China, India, Japan.
[C]Base period March 1929.
[D]Base period 1929.

White (1935) investigates three floating-rate experiences. Exchange-rate movements typically precede price movements; therefore PPP is rejected. “Nothing in the data…supports the sequence predicted by the purchasing power parity theory” (White, 1935, p. 262). Of course, this is a negative finding for PPP only as a causal, not an equilibrium, relationship.

Broadberry and Taylor (1992) examine all pairs in the country group United States, United Kingdom, France, Germany—as in Table 20 for the 1920s. They cannot reject that the real exchange rate is I(1), a failure of PPP. Cointegration results, which pertain to equilibrium PPP, are mixed. Granger causality tests, which address causal PPP, are also mixed. For full samples, prices never Granger-cause exchange rates, but the reverse is sometimes found. Only for subperiods of freely floating rates is there some evidence of prices Granger-causing the exchange rate.

8. interwar period—episodes encompassing both fixed and floating exchange rates

Table 23 lists studies that treat the interwar period as a broad expanse, incorporating fixed and floating exchange rates in the same sample. Young (1938) finds that there are subperiods defined by PPP and the exchange rate alternately moving together (during one subperiod) and diverging (during the next subperiod). This is not good evidence for PPP.

<table>
<tr><th colspan="9">Table 23
Testing of PPP Theory, Interwar Period: Fixed and Floating Exchange Rates</th></tr>
<tr><th>Study</th><th>Time Period</th><th>Countries</th><th>Base Period</th><th>Specification[A]</th><th>Price Variable</th><th>Other Variables</th><th>Technique</th><th>Results</th></tr>
<tr><td>Young (1938)</td><td>1912-1937 (M)</td><td>U.K.</td><td>1913</td><td>bivariate</td><td>WPI</td><td></td><td>comparative-static computation, graph (e)</td><td>mixed</td></tr>
<tr><td>Bunting (1939)</td><td>1919-1936 (M)</td><td>U.K., France</td><td>1926</td><td>bivariate</td><td>WPI</td><td></td><td>comparative-static computation, graph (e, c)</td><td>negative</td></tr>
<tr><td>Katano (1956)</td><td>1926-1935 (A)</td><td>Japan</td><td>1930</td><td>univariate</td><td>WPI</td><td>balance of payments</td><td rowspan="2">comparative-static computation, table (e), correlation (e)</td><td>mixed</td></tr>
<tr><td>Katano (1957)</td><td>1921-1936 (A)</td><td>Japan</td><td>1930</td><td>bivariate</td><td>WPI</td><td></td><td>mixed</td></tr>
<tr><td>Bernholz, Gärtner, Heri (1985)</td><td>1914-1933 (A)</td><td>France</td><td>1914</td><td>univariate</td><td>RPI</td><td></td><td>computation of maximum, period-end real exchange rate (e)</td><td>mixed</td></tr>
</table>

A = annual, M = monthly
WPI = wholesale price index, RPI = retail price index
e = equilibrium relationship tested directly, c = causal relationship tested
[A] Base country always United States.

Bunting (1939) graphs the exchange rate against PPP, with the latter alternatively lagged 0, 1, 2, and 3 periods. This is a logical way of assessing causal PPP, even though it is defective for lack of attention to nonstationarity. As Bunting (1939, p. 293) states, “not to allow a lag is to suppose that changes in domestic price levels will be immediately acted upon by foreign buyers.” Even with the lags, there are substantial deviations between the PPP and the exchange rate, and in opposite directions for France and the United Kingdom. Bunting (1939, p. 299) judges: “This is damaging statistical evidence against the purchasing power parity theory.”

Katano (1956, 1957) computes a number of correlation coefficients; but these are largely devoid of meaning, because of the small number of observations and the danger of spurious correlation. His most interesting result is that deviation from PPP is related to divergence from pure inflation in the countries. Bernholz, Gärtner and Heri (1985) exhibit the usual result of PPP validated in the long run while violated in the short run.

9. miscellaneous periods—long-term

Table 24 lists miscellaneous long-term studies. The countries involved are Spain and Guatemala. Both countries were on floating exchange rates throughout the sample periods, with Spain moving from a free to a managed float in 1931. For 1914-1920, Delaplane (1934, p. 41) notes “the wide divergence of purchasing power parity from the [exchange] rate.” For the entire 1914-1933 period, his assessment of PPP is, at best, mixed: "In the light of Spanish monetary experience since 1913, one could not attribute more than a rough correspondence between purchasing power parity and exchange. At times the two lines parallel each other, but the change in the peseta quotations preceded and frequently surpassed the alteration in price parity" (Delaplane, 1934, p. 211). Using Delaplane's data for the subperiod 1920-1929, Yeager (1976, p. 220) takes a more-sanguine view of PPP: "The actual rate kept within the range of 121.5 percent below to 12.5 percent above purchasing-power parity in 82.5 percent of the months."

Table 24
Testing of PPP Theory: Miscellaneous Periods, Long-Term

Study	Country	Time Period	Specification	Base Country	Price Variable	Nonstationarity		Technique	Result
						Test	Other		
Delaplane (1934)	Spain	1914-1920 (A)	bivariate[A]	U.S.	WPI			comparative-static computation, table (e)	negative
		1920-1933 (M)	bivariate[A]	U.S.	WPI			comparative-static computation: graph, table (e)	mixed
Yeager (1976)	Spain	1920-1929 (M)	univariate[A]	U.S.	WPI			comparative-static computation, table (e)	positive
Schweigert (2002)	Guatemala	1897-1922 (A)	trivariate	U.S.	Money stock (Guatemala), PGDP (U.S.)	ADF, PPP (crur)	logs	cointegration (ec)	positive
Sabaté, Gadea, Serrano (2003)	Spain	1870-1935 (A)	univariate	U.K.	WPI	PVC (rur)	logs		positive

A = annual, M = monthly
WPI = wholesale price index, PGDP = GDP deflator
PVC = Perron-Vogelsang-Clemente
e = equilibrium relationship tested directly, ec = equilibrium relationship tested via imposed causal relationship
crur = cannot reject unit root, rur = reject unit root
[A]Base period 1913.

Sabaté, Gadea and Serrano (2003) examine the Spanish experience over an even longer period than Delaplane. Allowing for structural breaks in the real-exchange-rate series enables rejection of a unit root. They conclude: "Thus, by considering the shocks captured by the breaks, we can accept long-run PPP as *a good first approximation to describe the salient characteristics of the real exchange rate* during the period from 1870 to 1935" (Sabaté, Gadea and Serrano, 2003, p. 625) [italics in original].

Schweigert (2002) uses the money stock to proxy the Guatemalan price index, for which a direct series does not exist. This representation is in the Cassel-Keynes tradition, absent price data (see Tables 7-8 in section 5 above). Results are excellent for PPP. The exchange rate, U.S. price, and Guatemalan money stock are found to be cointegrated. With the coefficient of the exchange rate normalized to unity, one cannot reject the hypotheses of symmetry and proportionality (coefficients of U.S. price and Guatemalan money one and minus one, respectively).

V. Other Applications of PPP in Economic History

"One blames politicians, not for inconsistency, but for obstinacy."—Keynes (1931 [originally published in 1928], p. 113)

1. analysis of U.S. return to gold standard in 1879

The successful PPP testing for the greenback period, on the part of Kindahl (1961) and Officer (1981), is based (wholly, for Kindahl; in part, for Officer) on real-exchange-rate computations (see section IV.3). These authors put their computations to work to determine (a) the range of real appreciation of the greenback for successful return to the gold standard, and (b) the first year in which a successful return could occur. For (a), the technique is simply to observe the range of the real exchange rate in the postbellum period but excluding 1877-1879, which are years of unusual capital outflow. Table 25 shows the resulting estimated ranges, all of which assume no capital movements. If resumption is to resume at the prewar parity (as in fact did happen), then the U.S. price index could exceed the U.K. price index by a value within the specified range (with both indexes relative to base year 1860). With capital inflow, the real exchange rate (or PPP, with no change in the nominal exchange rate) could exceed the upper limit. With capital outflow, it might have to fall below the lower limit.

Table 25
A Priori Range of Real Appreciation of Greenback for Successful Return to Gold

Study	Price Variable	Range[A] (percent)
Kindahl (1961)	WPI	9 to 27[B]
	WPI	8 to 18[C]
Officer (1981)	PGNP	-3 to 18[B]

WPI = wholesale price index, PGNP = GNP deflator
[A]Base period 1860.
[B]Objective estimate.
[C]Subjective estimate.

To answer (b), one approach is to find the earliest year in which the real exchange rate falls within the estimated range; but the range might be considered too broad for a confident return and maintenance of the gold standard. Consider, rather, a stronger criterion: the earliest year at which the real exchange rate reaches (or almost reaches) 100—the same value as in 1860. For Kindahl, that year is 1879, when his real exchange rate is 101 and the return to gold in fact occurred. For Officer, the year is 1875, when his real exchange rate is 100 and the Resumption Act was passed. That Act specified a return to the gold standard on January 1, 1879—which in fact happened. To some historians of the period, Officer's answer would be too optimistic. For example, Friedman and Schwartz (1963, p. 48) write that "the act was little more than the expression of a pious hope." However, they go on to state: "Resumption might well have been successful a year or more earlier than the date set and certainly could have occurred later"—Friedman and Schwartz (1963, p. 85).

2. establishment and assessment of a fixed exchange rate in interwar period

This, final, section discusses the use of PPP by government in connection with the setting of a new exchange rate. Following criterion 1 for the survey of studies of PPP testing (see section III.1), 1939 is the final year of interest. Then there are four cases of PPP computations by government in order to establish a new, or return to a former, exchange rate: the United Kingdom (1925), France (1926), Czechoslovakia ((1934), and Belgium (1935).

The U.K. return to gold on April 28, 1925 is the (sole) case of a government predetermining the exchange rate—in this case the prewar gold parity—and using PPP to measure the amount of price-level adjustment at home or abroad required to maintain the rate. The other countries applied PPP to compute the new exchange rate, though less so in France than in the other two countries.

No doubt the U.K. experience is the most famous of all governmental applications of PPP. The floating pound had appreciated from 10 percent to less than 2 percent below parity—caused by anticipation of a return to parity, whereupon the prewar exchange value of the pound ($4.86656 per pound) was restored. There was never a question that return to the gold standard would take place, and at the prewar rate. As Sayers (1960, p. 314) comments: "The restoration of the gold standard, at a tacitly assumed rate of 4.86, was government policy throughout…." Moggridge (1969, p. 14) agrees: "The Authorities had as their primary aim a return to gold…a return to the pre-war parity." There was never any choice as to the fact of return and the rate. According to Sayers (1960, p. 317), one of the advisers of Winston Churchill, Chancellor of the Exchequer, told him: "There's no escape; you have to go back [to gold at the prewar parity]; but it will be hell."

For the authorities, the only question was timing: when the gold standard would be re-established. Churchill's advisers used the WPI in their PPP computation, which Keynes criticized for virtually validating the existing exchange rate. "This led them to think that the gap to be bridged was perhaps 2 or 3 per cent…."—Keynes (1931 [originally published in 1925], p. 250). So the return to gold occurred on April 28, 1925.

Both contemporary and later economists used PPP to determine the overvaluation of the pound upon re-adoption of the gold standard. Their findings are reported in Table 26. Excluded from the table are computations based on wages or export price indexes, as well as estimates emanating from more-general models of exchange-rate determination.

Table 26
Estimates of Overvaluation of Pound in 1925[A]

Study	Base Country[B]	Price Variable[C]	Overvaluation[D] (percent)
Keynes (1931) [originally published in 1925]	U.S.	WPI	2 to 3[E]
		RPI [G]	10 to 12[E]
Cassel (1925b, 1926)	U.S.	WPI	4-5[F]
Gregory (1926)	U.S.	RPI[G]	10[H]
		RPI	-1[I]
Walter (1951)	U.S.	WPI	3[J]
Moggridge (1972)	U.S.	WPI	0 to 1
	.	RPI	1 to 5
		RPI [G]	9
		PGNP	11
Dimsdale (1981)	U.S.	WPI	1
	.	RPI	4 to 5
		PGNP	11
		PCONS	14
Redmond (1984)	U.S.[K]	WPI	-3 to 1
		RPI	0 to 9[G]
		PGNP	-1 to 11
		PCONS	14
	France	WPI	15
		RPI	44
	Belgium	WPI	12
		RPI	23
	Italy	WPI	18
		RPI	28
	Scandinavia[L,M]	WPI	-4
		RPI	6
	Empire countries[L,N]	WPI	-5
		RPI[O]	12
	ten countries[L,P]	WPI	7
		RPI	22
	19 countries[L,Q]	WPI	7
	16 countries[L,R]	RPI	23
Matthews (1986)[S]	U.S.	WPI	-3 to 1
		RPI	1 to 9[G]
		PGNP	11
		PCONS	14
Taylor (1992)	U.S.	WPI	5[T]

WPI = wholesale price index, RPI = retail price index, PGNP = GNP deflator,
PCONS = consumption deflator

[A]Year 1925, except where otherwise noted.

[B]Base period prewar, generally 1913.
[C]Excludes estimates based on wages or export price indexes.
[D]Technique comparative-static computation, except where otherwise noted.
[E]Months prior to return to gold.
[F]March-April 1925.
[G]Massachusetts index for U.S.
[H]April 1925.
[I]June 1925.
[J]May 1925. Computed by present author from data in Walter.
[K]Based in part on Moggridge and Dimsdale.
[L]Effective exchange rate, composite (average of bilateral and global) export-plus-import weights.
[M]Denmark, Sweden, Norway.
[N]Canada, India, South Africa, Australia, New Zealand.
[O]Excluding New Zealand.
[P]U.S., Canada, India, Japan, Belgium, France, Italy, Netherlands, Sweden, Switzerland.
[Q]"Ten countries" plus South Africa, Egypt, Czechoslovakia, Australia, Denmark, Norway, Argentina, New Zealand, Spain.
[R]"19 countries" minus Argentina, New Zealand, Spain.
[S]Based on Redmond and Moggridge.
[T]May 1925. Obtained by solving estimated error-correction model for long-run steady-state equilibrium exchange rate.

The earliest such computation was apparently made by Keynes himself. He contrasted the government WPI-based estimated overvaluation of 2-3 percent, with his own RPI-based figure of 10-12 percent. The former estimate was considered biased downward, the latter (in conjunction with PPP based on wages and prices of manufactures) "a much better rough-and-ready guide for this purpose…than are the index numbers of wholesale prices" (Keynes, 1931 [originally published in 1925], p. 250). However, as first pointed out by Gregory (1926), Keynes used RPI figures form the state of Massachusetts rather than the national U.S. data of the Bureau of Labor. The presumed reason, according to Gregory, is that only the former series at the time was published on a regular basis. Using the national figures, Gregory obtains results in accord with those of Churchill's advisors. Cassel (1925b, 1926) offers a WPI-based estimate slightly above that ascribed by Keynes to Churchill's advisors.

The computations of later writers use a broader array of indexes and base countries. Moggridge (1972) was the first author to employ the GNP deflator—a superior price index than the WPI and RPI—and finds overvaluation to be 11 percent, consistent with Keynes. Moggridge (1972, p. 105) writes: "An exchange rate at least 10 per cent lower than $4.86 would probably have been somewhat more appropriate for sterling." Dimsdale (1981), in addition to the estimates shown in the table, computes a real effective exchange rate for sterling versus 11 currencies, but only from 1920 and on a 1929 rather than prewar base. The work of Redmond (1984) is impressive for the array of alternative base countries as well as for effective exchange rate computations. The estimate of

Taylor (1992) is based on an error-correction model, and is included because the model is within the PPP rubric.

Certainly, the estimates of overvaluation of the authors have considerable variation. Perhaps most trustworthy are Redmond's figures based on RPI and the effective-exchange-rate concept. These estimates suggest substantial overvaluation, which is consistent with the U.K. post-return experience of balance-of-payments deficits, deflation, and unemployment. Keynes predicted this in 1925, and he was right!

France re-adopted the gold standard on June 25, 1928, with a par value of 124.21 francs per pound sterling. This emanated from a gold par of exchange only slightly greater than 1/5th the prewar value, when mint parity was 25.225 francs per pound. The genesis of the new par value occurred in 1926, when several French officials made PPP computations yielding ranges of a stabilized rate. The best source of this history is Mouré (1996). In August, Pierre Quesnay's calculations, using WPI and Germany as the base country, yielded appropriate stabilization of 160-170 francs per pound. In November, Jacques Rueff's PPP computations employed both WPI and RPI price indexes again with Germany as base country. He found the desired stabilization rate to be 120-145. In the same month, Charles Rist recommended the range 140-160.

In fact, the franc was appreciating in the foreign-exchange market. To stem this appreciation, at least temporarily, on December 20, 1926, Prime Minister Raymond Poincaré authorized the Bank of France to stabilize the rate via exchange-market intervention. This was a decision based on fear that appreciation would result in recession and unemployment and reduce Poincaré's political support within a coalition government. "PPP calculations did not decide the stabilization in December 1926" (Mouré, 1996, p. 144). However, as Mouré (1996, p. 144) comments, "the economists' arguments were not without effect." Stabilization was at about 122 francs per pound and the return to the gold standard in 1928 at 124.21. These figures are close to the lower bound of Rueff's PPP computations. Mouré (1996, p. 148) writes: "With regard to choosing a rate of stabilization, PPP calculations offered evidence that was of interest but not decisive…"

Table 27 provides estimates of undervaluation of the franc. The extent, not the direction, of deviation from PPP is the only issue. There is no doubt that undervaluation of the franc worsened the situation of the British, who overvalued the pound. However, Keynes (1930 [originally published in 1928], p. 114) judged that "the franc…fixed …at about one-fifth of its pre-war gold value…The figure finally chosen seems about right."

Yet Keynes states that a PPP computation would involve "a gold value of the franc nearer to one quarter (100 francs to the £) than to one-fifth of the pre-war value" (Keynes, 1930 [originally published in 1928], pp. 114-115). This suggests about a 20 percent undervaluation. However, Keynes provides reasons—crudeness of French price indexes, room for domestic prices to rise, effect on export industry, budgetary implications, and avoidance of capital loss on foreign-exchange reserves of the Bank of France—why the

French authorities were wise not to follow his computed PPP. All but one of the other estimates in Table 27 are below 20 percent.

It is not clear whether the French authorities deliberately undervalued the pound. According to Mouré, the concern was domestic macroeconomic stability, which explains why (1) the de facto stabilization rate in 1926 was undertaken to keep the franc from appreciating further, and (2) the de jure stabilization rate in 1928 was close to the de facto rate established in 1926.

Table 27
Estimates of Undervaluation of French Franc in 1928[A]

Study	Base Country[B]	Price Variable	Undervaluation[C] (percent)
Keynes (1930 [originally published in 1928], pp. 114-115)	U.K.	unstated	20
Cassel (1936)	U.K.	WPI	11[D]
Walter (1951)	UK	WPI	6[E]
	US	WPI	12[E]
Sicsic (1992)	nine countries[F]	WPI	7-12
		RPI	28

WPI = wholesale price index, RPI = retail price index
[A]Year 1928, except where otherwise noted.
[B]Base period prewar, generally 1913.
[C]Technique comparative-static computation.
[D]June 1928.
[E]Computed by present author from data in Walter.
[F]Belgium, France, Germany, Italy, Netherlands, Sweden, Switzerland, U.K., U.S. Effective exchange rate, global export weights.

In February 1934, Czechoslovakia devalued the crown by 16 2/3 percent. The devaluation rate was based on a WPI PPP computation. Haberler (1961, p. 49, n. 37) comments that "exactly the same mistake was made [as in the United Kingdom in 1925]." The interpretation of Nurkse (1944, p. 128) is that the rate left no margin for economic expansion, putting downward pressure on the exchange value of the domestic currency. In any event, Czechoslovakia had to devalue a second time, in October 1936. Further discussion of the Czech experience is in League of Nations (1936, pp. 49-52).

The final case is devaluation of the Belgian franc in 1935. The devaluation rate of 28 percent was decided on the basis of PPP computations, with RPI as the decisive price concept. This experience is discussed in League of Nations (1936, pp. 49-50), Nurkse (1928, p. 128), Triffin (1937), Garnsey (1945), and Officer (1982, pp. 143-144). Unlike the case of Czechoslovakia, the Belgian devaluation was successful.

VI. Concluding Comments

"Under the skin of any international economist lies a deep-seated belief in some variant of the PPP theory of the exchange rate."—Dornbusch and Krugman, 1976, p. 540

With apologies to Gustav Cassel, the above quotation is perhaps the most famous in all writings of PPP. The use of PPP in analyzing historical experiences, and sometimes even in establishing these experiences, has been documented in this survey.

PPP theory and application have tensions and inconsistencies. Only some of these follow. PPP is perhaps the easiest exchange-rate norm to calculate; yet any such simple computation has the serious danger of a spurious result. Absolute PPP is the more-basic theory; yet, for lack of data, all historical applications apply only relative PPP. Floating exchange rates are the most logical regime in which PPP would work; yet applications to fixed exchange-rate regimes are made without qualms. PPP is a theory of the *equilibrium* exchange rate; yet evaluation of the theory takes the form of comparison of the PPP prediction with the *actual* rate. Relative PPP is oriented to monetary changes being dominant; yet the theory is often applied to experiences without assessment of the relative importance of monetary to real changes or shocks.

Notwithstanding all these problems, PPP theory has stood the test of time. This survey documents that researchers have employed PPP to examine exchange-rate experiences from the 1720s to the 1930s. Interest in the relationship of PPP to exchange-rate behavior in the post-Bretton Woods era (that is, since 1973) has, if anything intensified. The explosion of PPP studies pertaining to that era will one day be classified as economic history, and another historical PPP survey might result.

PPP theory is easy to criticize; but, certainly in the history of exchange rates, use of the theory is hard to avoid. Also, governments or central banks seeking to find the equilibrium value (or range of values) for their currencies would do well to use PPP theory to check on results obtained by other, perhaps more-sophisticated, means.

In tribute to Gustav Cassel, the greatest expositor and proponent of PPP, it is only fitting to close with a quotation of his own:

"If those critics, who express themselves in such vague general terms, were allowed to have their own way, the entire theory of the purchasing-power parity would have to be thrown to the winds, and we should be left in as much doubt as ever as to the real basis of the rates of exchange."—Cassel (1924, p. 68)

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