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The Purchasing Power Parity Criterion for Stabilizing Exchange Rates

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Abstract

The use of purchasing power parity as a basis of fixing exchange rates among industrial countries, as proposed by McKinnon, is discussed and contrasted with alternative interpretations of the PPP doctrine. Major policy implications of such a regime are emphasized. Furthermore, a new technique for estimating PPP exchange rates which makes use of price pressure exerted by exchange deviation is introduced. This method is capable of solving the "base-year" problem more satisfactorily than the traditional Cassel-Keynes methodology. Estimated yen/dollar and mark/dollar PPP exchange rates are close to estimates derived using other methods.

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Summary

The use of purchasing power parity (PPP) as a basis for stabilizing and eventually fixing exchange rates among industrial countries has been proposed by Professor McKinnon. While the concept of PPP is frequently used today, McKinnon's interpretation is fundamentally different from other interpretations of the PPP doctrine. McKinnon's PPP is a normative criterion, independent of whether PPP actually holds in the long run under the current system. It constitutes part of a comprehensive reform proposal that emphasizes international monetary cooperation to achieve long-run price stability among highly integrated economies. The key ingredients of his proposal are: first, commitment to permanently fixed nominal exchange rates; second, use of the price of a broad basket of internationally tradable goods as the nominal anchor of the system; and third, a relative-price adjustment mechanism based on absorption change and divergent price movements of various nontradable goods.

McKinnon stresses the importance of internal price movements as opposed to changes in the external terms of trade when the exchange rate fluctuates. Deviation of the exchange rate from PPP exerts "price pressure" on the tradable sector of the economy, which partially offsets the initial deviation and initiates the process of differential inflation across countries to re-establish PPP over time. In contrast, the exchange rate affects nontradable prices more indirectly and with longer lags.
As a consequence, the relative price between tradable and nontradable goods is systematically altered in proportion to the deviation from PPP.

One can exploit this fact statistically to estimate the PPP exchange rate, namely, the path of the hypothetical exchange rate that would have exerted no price pressure either on one economy or the other. The methodology consists of two basic price and cost equations (which are derived from a structural model) and offers a more satisfactory solution than existing methods to the so-called base-year problem in estimating PPP. Using this price pressure approach, the yen/dollar and mark/dollar PPP exchange rates are estimated and compared with those derived from other approaches. These estimates are all close to each other. This demonstrates that estimating PPP, while not a trivial exercise, can be performed with scientific accuracy, and hence agnosticism about PPP exchange rates is unwarranted.

I. Introduction

Since the beginning of general floating in the early 1970s, unexpectedly large swings in the major exchange rates have spawned a lively debate as to whether and how the current international monetary system should be reformed. Opinions differ greatly, from the advocates of uncompromising laissez-faire in the foreign exchange market to the believers in the resurrection of the classical gold standard. Among those who favor imposing a new institutional framework to replace the current system, two economists stand out for presenting concrete proposals for the purpose of stabilizing major exchange rates.

John Williamson (1985) proposes a new regime based on adjustable target zones. The actual exchange rate is to be restricted to the proximity of the so-called fundamental equilibrium exchange rate (FEER), defined as "that which is expected to generate a current account surplus or deficit equal to the underlying capital flow over the cycle, given that the country is pursuing 'internal balance' as best it can and not restricting trade for balance of payments reasons" (p.14). It is immediately clear from this definition that the primary objective of Williamson's exchange rate policy is to control trade flows under certain conditions indicated above (the balanced trade criterion for exchange rate policy). His 1985 book demonstrates how to estimate FEERs step by step. Williamson's scheme is expanded to encompass a new fiscal and monetary policy mix in his more recent book with Marcus Miller (1987). It is proposed that the differentials in short-term interest rates should be used to achieve exchange rate targets whereas the average level of short-term interest rates be used to control global demand. In addition, fiscal policy shall be used to further adjust aggregate demand within each country. Their book also purports to show the superiority of the Williamson blueprint by a simulation of the large multicountry model (MCM) of the Federal Reserve Board.

Ronald McKinnon (1984, 1988a) has proposed a system of permanently fixed exchange rates based on purchasing power parity (PPP) and monetary cooperation among the United States, Japan, and West Germany (representing EMS). Unlike Williamson, McKinnon would use the fixity of exchange rates to simulate a common monetary standard--as if the world became a single currency area--and to stabilize the global price level of tradable goods (the PPP criterion for exchange rate policy). He believes that real adjustment can be done more smoothly under fixed exchange rates than under floating exchange rates, by letting non-tradable prices diverge while keeping the common tradable prices constant. McKinnon envisages an entirely different policy mix: monetary policies should be used to maintain exchange rate parities (which takes up N-1 degrees of freedom in the world of N currencies) and to jointly anchor the global price level (which takes up the last degree of freedom). As for trade imbalance, exchange rate policy does not have a comparative advantage in controlling domestic absorption--which is the only realistic way of correcting the underlying income-expenditure

imbalance in the short run--and should not therefore be used to target trade flows. Unwanted trade imbalance should be rectified by fiscal adjustment and other policies that affect domestic absorption more directly.

Thus, while calling for more stable exchange rates, the views expressed by Williamson and McKinnon form a sharp contrast. Numerous attempts will surely be made to further assess their proposals in the future as in the past. In this regard, however, McKinnon has not presented a formal technique for estimating PPP exchange rate targets which is certainly one of the most important operational aspects of his proposal to be evaluated. 1/ Estimating PPP exchange rates involves collecting price data and comparing them with a suitable statistical method, which in theory sounds much simpler than Williamson's unenviable task of guessing optimal capital flows, estimating the exchange rate elasticity of the current account, identifying the present cyclical position and macroeconomic policy stance, and using a large econometric model to arrive at FEERs. In practice, however, one will soon discover that estimating PPP is by no means a trivial task, conceptually or technically. The concept of PPP has become so broad and its applications so diverse that what is usually meant by PPP is often quite different from what McKinnon has in mind. And the popular method of estimating PPP, by updating the exchange rate in some arbitrary base year using subsequent price movements (which we will later call the Cassel-Keynes method) is inadequate in the present circumstances.

The purpose of this paper is to clarify the concept of PPP which is relevant in evaluating the McKinnon proposal, and to present a new, more statistically satisfactory way of estimating PPP exchange rates under the present floating exchange rate regime. This new technique, which shall be called the price pressure method, takes advantage of the property that relative tradable prices between two countries are systematically affected as the exchange rate deviates from its PPP level. While the price pressure method was born as a part of the PPP criterion of McKinnon and is therefore most naturally interpreted in its context, its validity also extends beyond the controversy surrounding the fixed versus floating exchange rate regime. The author believes that the price pressure method offers an extremely useful and economical way of estimating PPP exchange rates whatever the reason for such estimation.

1/ Previously, McKinnon estimated PPP exchange rates using the Cassel-Keynes method, with 1975-76 as the base period and producer prices as the preferred index. More recently, he has relied on the estimates derived by the long-run averaging method and the price pressure method which are presented later in this paper. However, formal exposition of these methods, especially the latter, has not taken place. For an informal discussion of these methods, see McKinnon and Ohno (1989).

The paper is organized as follows. The next three sections prepare the background material for presenting the price pressure method: Section II reviews various concepts and uses of PPP and distinguishes the PPP criterion for exchange rate policy as fundamentally different from other interpretations of PPP. Section III lays out the essential ingredients of the McKinnon proposal as compactly as possible. Section IV then turns to the technical issues of estimating PPP and sees what techniques are presently available to solve the "base-year" problem. After these preparations, the price pressure model is introduced in Section V. Section VI reports the empirical results of price-pressure estimation, using bilateral U.S.-Japan and U.S.-West Germany data. Concluding remarks are in the final section.

II. Purchasing Power Parity Today

The modern concept of purchasing power parity originated with the writings of Gustav Cassel (1918, 1921, 1922) in the unsettled monetary aftermath of World War I. It is well to remember that his most basic exposition of the PPP doctrine included both normative and positive statements. Cassel declared that (i) the PPP exchange rate, at which purchasing powers of different national currencies were equalized, was the only equilibrium or desirable rate; and (ii) the actual nominal exchange rate would tend towards the PPP level over time, provided the government did not intervene to prevent it. 1/ Thus, his theory had a happy implication that things would progress from chaos to harmony only if left alone by themselves.

Since Cassel's time, economists have long been fascinated with one aspect of the PPP doctrine or another. Today, PPP has many interpretations and applications, and different people often mean different things when they invoke PPP and its derivative concepts. At the outset of our study, therefore, we are well advised to devote some space in reviewing the most popular current uses of this doctrine. For the validity and usefulness of PPP cannot be evaluated independently of the way it is put to use. Moreover, the appropriate technique for estimating PPP exchange rates also hinges on the particular version of PPP one is interested in.

1/ These two sides of Cassel's (1921) concept of PPP are easily recognizable: "Given a normal freedom of trade between two countries, A and B, a rate of exchange will establish itself between them and this rate will, smaller fluctuations apart, remain unaltered as long as no alteration in the purchasing power of either currency is made and no special hindrances are imposed upon the trade" (positive, p. 36). "The purchasing power parities represent the true equilibrium of the exchanges, and it is, therefore, of great practical value to know these parities" (normative, p. 38).

1. The theory of exchange rate determination

The first, and perhaps the most traditional, version of the modern PPP doctrine is based on a purely empirical proposition similar to Cassel's second statement. It is the theory of exchange rate determination, where the nominal exchange rate is predicted to move so as to offset differential inflation rates across countries. 1/ This view is often (but not necessarily) combined with the monetary theory of inflation, where a typical causal link runs as follows: an exogenous increase in money supply relative to money demand bids up domestic prices, which in turn depreciates the nominal exchange rate. This interpretation of PPP with unilateral causation from (money and) prices to the exchange rate was dominant until the beginning of general floating in the early 1970s.

Correlation between domestic inflation and the nominal exchange rate has been historically well documented for countries with hyperinflation. However, for low-inflation countries, serious doubt has been thrown on the validity of PPP as a theory of exchange rate determination. Evidence suggests quite conclusively that PPP does very poorly in the short to medium run as far as major currencies in the 1970s and 1980s are concerned (Frenkel, 1981ab). More recently, however, attention is being directed to the statistical verification of long-run correlation between prices and nominal exchange rates--in other words, whether there is a notable mean reverting component in the low frequencies of real exchange rates (Huizinga, 1987; Mecagni and Pauly, 1987; Ohno, 1989a). While researchers are yet to arrive at a definitive conclusion, it appears that the predictive power of PPP is much higher in low frequencies (typically long-run trends) than in high frequencies (month-to-month or even year-to-year fluctuations).

However, one point must be considered in this connection. Statistical correlation between prices and exchange rates does not necessarily reveal causality. Mean reversion of real exchange rates could occur either because exchange rates adjust to prices, or because prices accommodate exchange rate movements. In the first case, PPP is truly a theory of exchange determination. In the second case, PPP becomes a theory of price determination via commodity arbitrage, with the exchange rate as one of the forcing variables. As far as the yen/dollar exchange rate is concerned, causality seems mutual (Ohno, 1989a). Prices of tradable goods do adjust to changes in the nominal exchange rate, but adjustment is much smaller than what is required to re-establish PPP.

1/ In The New Palgrave Dictionary of Economics, Vol. III (1987), Dornbusch opens the discussion of PPP thus: "Purchasing Power Parity (PPP) is a theory of exchange rate determination. It asserts (in 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" (p. 1075).

In the discussion of PPP as a theory of exchange rate determination, much (perhaps too much) attention has been paid to the fact that nationally compiled price indices have different weights, from Keynes (1923a) to Samuelson (1964) to Dornbusch (1987). The PPP doctrine is often discredited, because even in an ideal situation of the law of one price for every individual good, PPP calculated using these imperfectly comparable indices will diverge from the actual exchange rate unless relative prices among individual goods remained the same--an unlikely proposition. Many formulas for measuring PPP disparity due to relative price changes have been invented and taught at universities as if this were the essence of the PPP doctrine. While practically important, the purely statistical problem of constructing a standard commodity basket should not detract one from other important aspects of PPP.

2. The concept of long-run equilibrium

Quite apart from the empirical validity of PPP, theorists are willing to accept PPP as one of the building blocks for constructing various models of exchange rate determination. The two most standard theories of exchange rates--the Dornbusch overshooting model and the portfolio-balance model--and many other models contain PPP as the long-run equilibrium rate toward which people expect the actual exchange rate gravitates after an initial shock.

PPP as the (very) long-run equilibrium is an appealing concept, since international goods markets can hardly be considered in full equilibrium unless the law of one price prevails in some form or another. It is true that many manufactured goods are imperfect substitutes to each other (as Japanese and American automobiles are), and that commodity arbitrage usually takes a considerable amount of time. Nonetheless, these qualifications only widen the margin within which the law of one price is deemed holding. If proper account is taken for transportation cost and quality changes, the trend of indefinite and persistent divergence from the law of one price is inconsistent with the notion of long-run equilibrium in goods markets under largely free trade.

For the purpose of theory, whether PPP accurately predicts the long-run movement of exchange rates empirically and *ex post* is less important, than the assumption that, *ex ante*, people do expect exchange rates to follow the paths implied by PPP in the long run.

3. The conversion factor for income comparison

PPP is also used for a quite different purpose, namely, for the comparison of income and living standards of countries with dissimilar economic characteristics. Many international organizations have a practical need to determine and rank (say) per capita incomes of its member countries, according to which its lending and other policies might be set. Such comparison requires that all local-currency entries be converted to a common unit, typically the U.S. dollar.

However, there is a well-known problem in using the actual exchange rate as the conversion factor. Many less developed countries (LDCs) have grossly overvalued exchange rates which makes the comparison of living standards unrealistic. 1/ Some LDCs have multiple exchange rates, where the appropriate rate for conversion is not obvious. For developed countries, the problem is equally serious. When there are large swings in the exchange rates among major currencies, GNP, per capita income, the cost of living, and so on, of one country versus another are changed dramatically, although productivity or resource endowment remains the same within each country.

In order to avoid such biases and spurious changes in the measurement of national income, the World Bank and OECD regularly compute more realistic conversion factors based on the principle of absolute PPP (Ward, 1985; Kravis, 1986). They collect the local-currency price of each major category of national expenditure, and use them to update the conversion factors for international comparison. Naturally, the commodity basket they use contains many nontradable goods and services as well as tradables. In addition, their price data are evaluated at market price, that is, they include net indirect taxes. These choices are reasonable given the purpose of their exercise. However, because of their methodology, these PPP estimates are not directly transferable to other applications of the PPP doctrine. For instance, there is no reason to believe that actual exchange rates would converge to the OECD or World Bank estimates of PPP which include prices of nontradables. Nor would one regard the estimated conversion factors as the proper target zones for stabilizing exchange rates.

4. The normative policy criterion

Finally, there is another important aspect of PPP, which serves as the normative benchmark for guiding monetary and exchange policies.

For many LDCs wishing to expand and diversify the export base, it is important to have "realistic" exchange rates which allow the tradable sector to compete effectively with foreign products. More often than not, however, countries with a lapse in fiscal and monetary discipline permit high domestic inflation to develop and eventually price themselves out of international competition. When this occurs, devaluation of the home currency is often necessary to restore the lost price competitiveness. In the absence of detailed price data, one would normally take the most recent period prior to a bout of inflation as the base, and use relative price indices to calculate the required amount of corrective devaluation.

1/ One important reason for this is the relatively cheap nontradable goods and services in LDCs. When incomes are compared using exchange rates which reflect competitiveness in the tradable sector, incomes in LDCs tend to be understated.

For developed countries, the idea of using PPP as a policy criterion was proposed recently by McKinnon (1984, 1988a). The industrial world has become integrated economically not only through trade but also financially to such an extent that McKinnon contends the only practical way to ensure global price stability is through coordination rather than through independent and inward-looking policies of individual countries. While a new and internationally common currency is unlikely to emerge and replace national currencies in the foreseeable future, McKinnon believes that the major industrial economies can simulate a situation of such a common monetary standard by means of monetary cooperation.

Policy coordination that McKinnon proposes is a unique one. It is first and foremost a monetary proposal, rather than a mixture of fiscal, monetary, and structural recommendations. Its primary objective is to attain long-run price stability among major industrial countries. The key ingredients of his proposal are (i) commitment to permanently fixed nominal exchange rates; (ii) use of the price of a broad basket of internationally tradable goods as the nominal anchor of the system; and (iii) the relative-price adjustment mechanism based on the divergent price movements of various nontradable goods. At the operational level, McKinnon proposes a few basic rules that the central banks of the United States, Japan, and West Germany should abide by.

It is this normative interpretation of PPP, as proposed by McKinnon, that motivates us to estimate the current level of PPP exchange rates among the U.S. dollar, Japanese yen, and Deutsche mark. This is the version of PPP which is expanded to encompass a sweeping reform of the international monetary system as well as a radical change in the way macroeconomic policies are conducted in each country. In the following section, we will take a closer look at the McKinnon proposal, before we turn to the technical question of how to estimate PPP exchange rates under the current floating exchange rate regime.

III. PPP as a Policy Criterion

In this section, the PPP criterion for stabilizing exchange rates as proposed by McKinnon (1984, 1988a) is reviewed. We will discuss in turn the concept of PPP, its policy implications, the relative price adjustment mechanism, and its operational rules envisaged by McKinnon. This section provides the background against which our later exercise of estimating PPP exchange rates is conducted.

According to the PPP criterion proposed by McKinnon, the nominal exchange rate should be set at a level where the prices of a common broad basket of internationally tradable goods in different countries are equalized, when converted to a single currency unit using these exchange rates.

Under a system of permanently fixed exchange parities and free trade, PPP in tradable goods is a trivial proposition because it is always satisfied; for there will be ample time for international commodity arbitrage to assert itself. 1/ Under a floating exchange rate regime, however, PPP in tradable goods is far from trivial. The prices of most tradable goods (with the exception of precious metals and certain primary commodities which are traded in efficient international markets) are sticky, while exchange rates can change rapidly. As a consequence, violation of the law of one price becomes the rule rather than the exception, especially for manufactured goods. Under such circumstances, PPP in tradables will not hold unless the exchange rate is set at the "correct" level. The problem we address in the remainder of this paper is how such a "correct" level can be estimated so as to make the transition from the present regime to the new regime proposed by McKinnon as smooth as possible.

However, the PPP criterion of McKinnon goes beyond estimating the "correct" starting values for a new international monetary regime. The more important aspects of his proposal involve policy implications. In essence, his PPP criterion constitutes a proposal for comprehensive reform in the international monetary system and the general principles of macroeconomic policy making. The most important policy implications are discussed below.

1. Commitment to permanently fixed exchange rates

As is well known, fixing nominal exchange rates among major industrial countries implies that these countries will lose independence in monetary policy and subject themselves to a common monetary policy of the whole system. Money supply of each country will be endogenized through the obligation to maintain official parities, and interest rates are also expected to converge internationally. Furthermore, each member of the system will tend to have the same rate of inflation in tradable goods, as international commodity arbitrage asserts itself.

This will provide an environment of long-run monetary stability in which national economies become ever more integrated through trade and finance, as if they were regions of a common monetary standard. McKinnon considers lasting stability in the conversion rates of national currencies as essential in promoting growth and efficiency of the world economy. Underlying this is his belief that the industrial economies have become highly interdependent in the 1970s and 1980s, that most macroeconomic shocks of these decades have had international origins, and that authorities' outmoded obsession for independent action is unattainable and positively harmful in its consequences.

1/ We assume that PPP is computed using price indices with identical weights, and that transportation costs are negligible.

Then there is the famous N-1 problem. To fix exchange rates among N countries, only N-1 independent actions are necessary. How to allocate the remaining one degree of freedom among member countries has been a major sticking point in designing a system of fixed parities. McKinnon's answer is to assign it for anchoring the common price level of tradable goods.

2. The nominal anchor

The PPP criterion adopts the common price level of internationally tradable goods as the nominal anchor of the new international monetary system. Generally speaking, a nominal anchor is something--perhaps some reference index--which serves as an "anchor" to prevent instability of various nominal variables in the system, and especially of the general price level. Ideally, authorities are obliged to systematically adjust their policies so as to stabilize this index over time. 1/ It can be arguably said that none of the international monetary systems in the past had an effective nominal anchor. The worldwide price trend under the 19th century gold standard was at the mercy of supply and demand conditions of gold, over which authorities had little control. The Bretton Woods system contained the undesirable mechanism in which inflationary pressure in the United States (the center country) was amplified and transmitted abroad through the unilateral obligation to intervene by the others--the Fed determined the price trend for the rest of the world. The current floating arrangement, where each country mainly minds its own domestic price trends, lacks a reliable mechanism to prevent worldwide inflation or deflation.

For the success of any international monetary system, it is imperative that an explicit provision be made for a workable nominal anchor. McKinnon's PPP criterion proposes that the price of a broad basket of tradable goods, including both primary commodities and manufactured products, be such an anchor. The advantage of this is twofold.

First, it strikes a proper balance between relevance and controllability which are two requirements for a good nominal anchor. On the one hand, nominal GNP and GNP deflator are highly relevant for economic well-being but come with unacceptably long lags and frequent revisions. On the other hand, gold and other primary commodity prices are reported daily with precision but have only remote consequences for national welfare. The price of a broad basket of tradable goods

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1/ Keynes put it thus: "it would promote confidence, and furnish an objective standard of value, if, an official index number having been compiled of such a character as to register the price of a standard composite commodity, the authorities were to adopt this composite commodity as their standard of value in the sense that they would employ all their resources to prevent a movement of its price by more than a certain percentage in either direction away from the normal" (Keynes, 1923b, pp. 215-216).

(something like producer or wholesale price indices) is more desirable because it is both meaningful and readily available with only a short delay.

Second, it is a natural, and the only consistent, nominal anchor in a system based on economic integration and fixed parities. When relative prices change within each country, it is obviously impossible to stabilize all prices. Suppose there is a tendency for tradable prices to fall relative to nontradable prices because of productivity differential between these sectors. Suppose further that each country has a different degree of internal price divergence. 1/ In such a situation, if each country attempted to stabilize nontradable prices (or a combination of tradable and nontradable prices), PPP in tradables would require that nominal exchange rates be adjusted over time. This is inconsistent with maintenance of fixed exchange rates. Worse, once parities were allowed to change, expectations about future realignments would be unleashed and foreign exchange markets would soon be dominated by "news." Orderly and gradual adjustment in exchange rates under free capital mobility is a very difficult proposition to implement, as we all learned in the 1980s.

3. The adjustment mechanism

This raises another important question: how should adjustment be made when there is a real shock--say, a shift in demand, a bout of technological breakthroughs, or a discovery of mineral resources--under a fixed exchange rate regime? A successful international monetary system must surely have an adjustment mechanism which can smoothly absorb these (mostly country-specific) real shocks. An ideal floating exchange rate regime was supposed to provide exactly such a mechanism. But its actual working has been constantly plagued with overshooting and misalignment. 2/

The relative price which concerns us here is not the price ratio of tradable goods in country A versus tradable goods in country B, but the price ratio between tradable goods and nontradable goods within a country. It is the latter price that directly affects an economy's resource allocation and trade flows. If McKinnon's PPP criterion is successfully launched, the world economy will have a common and stable price level of tradable goods in all major currencies. Relative price

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1/ Between 1975 and 1985, consumer prices rose 19.9 percent relative to wholesale prices in Japan. Corresponding figures for the United States and West Germany are 6.9 percent and -0.5 percent, respectively.

2/ McKinnon (1988a) argues that, upon discovery of natural gas or oil fields, the Dutch were better off under the Bretton Woods fixed-rate system of the 1960s because the ensuing reallocation of domestic resources proceeded gradually over the entire decade, than the British in the late 1970s whose currency appreciated rapidly in both nominal and real terms which wiped out a large chunk of British manufacturing in a matter of a few years.

adjustment then is effected by letting individual prices of both tradable and nontradable goods adjust freely, while keeping the price of a well-defined broad basket of tradable goods constant in every currency. 1/

Diverging internal prices has been a focus of many international trade theories, and is also a basis of the celebrated Scandinavian model of inflation. Empirically, such tendencies have been well documented in many studies, classically by Balassa (1964) and more recently by Marston (1987b). Historically, the Bretton Woods system offers a prominent example of a combination of fixed nominal exchange rates, stable tradable prices, and diverging nontradable prices. Throughout the 1960s, Japanese nominal wages rose at the annual rate of 11.3 percent while American wages increased only at 3.8 percent per year--no doubt a reflection of growth differential in labor productivity. All this while, the nominal yen/dollar rate was fixed at 360 and producer prices in either country were virtually unchanged, rising only 1.2 percent in Japan and 1.5 percent in the U.S. annually. In addition, Japanese money supply was largely endogenous to the commitment to the fixed parity--and indirectly to U.S. monetary policy. It necessarily rose much faster than in the U.S. in order to prevent imbalance in the Japanese balance of payments from emerging.

Some critics of McKinnon--notably Krugman and Baldwin (1987)--purport to show that a fixed exchange rate is inconsistent with adjustment to real shocks using a model with only one good in each country. They argue that, in order to eliminate undesirable trade imbalance, a change in relative price is necessary. Since their model has only one relative price--the exchange rate--it is obvious that the exchange rate must change if one wished to change the trade balance. However, it is equally obvious that their one-good-per-country model cannot refute the McKinnon proposal which presumes internal relative price adjustment between tradables and non-tradables. In fact, it is easily shown and intuitively clear that as soon as the Krugman-Baldwin model is expanded to include nontradable goods, there is no need to adjust the nominal exchange rate in order to execute adjustment (Ohno, 1989b).

Furthermore, no relative price adjustment--whether in the terms of trade or in internal prices--might be necessary to generate a transfer of purchasing power if economies were well diversified and highly integrated. In the traditional Heckscher-Ohlin real trade model, such extreme cases could arise when factor prices of labor and capital remained equalized internationally before and after the transfer (i.e., a shift in the consumption point relative to the production point).

1/ Needless to say, stability in the average of tradable prices is perfectly consistent with variability in the prices of individual tradable goods. If an innovation occurs in the production of integrated circuits, their absolute (hence relative) price will decline by the same amount in dollar, yen, and mark. It is also conceivable that the relative price between primary commodities and manufactured goods will steadily change while the overall tradable price level remains constant.

The additional assumption of international capital mobility would make factor price equalization more likely, and the need for price adjustment less likely. These results are not surprising from the viewpoint of the extensive transfer problem literature. Whether the transferor experiences a deterioration in the terms of trade is ambiguous and highly model dependent. In general, there is no presumption that relative prices should change in one way or another when a transfer occurs between countries with open and diversified economic structure (McKinnon, 1988b).

This brings us to the issue of trade imbalance under a fixed exchange rate regime. Under the McKinnon regime, PPP in and of itself would not guarantee balanced trade, nor would it be desirable to do so. When capital moves freely across countries, balanced trade (i.e., financial autarky) does not necessarily maximize welfare over time. But suppose the current trade deficit is too large from the viewpoint of intertemporal welfare maximization. McKinnon argues that, even then, necessary adjustment can be made without changing parities--in fact, this is a more efficient way to adjust than letting the exchange rate float. The existence of a trade deficit reflects the excess of absorption over production, and its correction requires policy which impinges directly on absorption (production is more difficult to control in the short run). A cut in fiscal spending or a tax increase would be effective. As a result of a reduction in domestic demand, nontradable prices would gradually fall, prompting a shift in production from nontradables to tradables and a shift in consumption from tradables to nontradables. Such adjustment in relative price--if necessary--will come slowly and most likely be small, but quite sufficient to induce the necessary capital flow. It is fiscal policy, rather than exchange rate policy, that has a comparative advantage in altering trade flows in a financially open economy.

4. The operational rules

The McKinnon proposal has a set of simple operational rules for the major central banks to follow. The first rule is to maintain the fixity of nominal exchange rate among member countries by symmetrical adjustment in monetary policy. For example, if a pressure developed to push the yen up against the dollar, the Bank of Japan should ease its monetary policy as the Fed tightened its own. This kind of operation can be routinely done by adjusting relative short-term interest rates daily or weekly. Only in a crisis situation would direct intervention in the foreign exchange market be necessary--in which case intervention should be symmetrical and unsterilized. Fixing parities would take up N-1 degrees of freedom, and ensure all member countries would have similar inflation rates in tradable goods.

The remaining one degree of freedom should be used to stabilize this common rate of tradable inflation. The Fed, the Bank of Japan, and the Bundesbank should constantly monitor the global price trend and, at the sign of global inflationary or deflationary pressure, act jointly to

decrease or increase the rate of world monetary growth without altering their relative positions. Given the difficulty in judging price trends, they may not always succeed in the short run. However, the most important thing is that tradable prices remain the same in the long run. As long as traders and investors are assured that the global price level will be roughly the same ten or twenty years hence as today, minor year-to-year variation in price levels would do no great harm.

In this connection, the crucial importance of credibility in the new system cannot be emphasized too much. A large part of whether a fixed exchange rate regime will stand or fall depends on whether people, and policy makers in particular, have faith in the system. If such confidence were firmly established, the system would withstand a most severe external shock--as the 19th century gold standard survived many a financial crisis. In the absence of such confidence, a forced system of fixed parities would collapse in time--as the failed attempt to restore the gold standard during the interwar period shows.

Finally, the McKinnon proposal differs substantially from the historical Bretton Woods system in three important respects. First, parities are fixed permanently and are not allowed to be revised because of "fundamental disequilibrium" or for any other reason. Second, a nominal anchor of the common tradable price level is placed at the heart of the system. In contrast, the nominal anchor of the Bretton Woods system was supposedly gold, but in reality hinged on U.S. monetary policy--which turned out to be a rather capricious mooring. Third, symmetry in action is preserved among the major three central banks. Needless to say, the Bretton Woods was characterized by asymmetry between American benign neglect and the responsibility to intervene by all other central banks.

IV. Estimating PPP: An Overview

We now turn to the task of estimating PPP exchange rates, and PPP in tradable goods in particular, under the current floating exchange rate regime. We will show that estimation can be done with reasonable accuracy and that many estimates using different methods are closely bunched together. This section summarizes the problem involved in estimating PPP exchange rates and briefly describes the currently available methodology to solve it. Later sections will introduce an entirely new technique of estimation based on "price pressure" exerted by the exchange rate.

If nominal exchange rates had been fixed for a long time and trade were fairly free, international commodity arbitrage should tend to align individual as well as average national price levels of goods that are subjected to international competition, although the prices of nontradable goods could diverge across countries (see the previous section). However, under a floating exchange rate regime where exchange rates move much faster than sticky prices do, there is no presumption

that the same tradable goods would cost similarly in different countries, and in fact they cost differently under normal circumstances (Isard, 1977; Krugman, 1987b; Hooper and Mann, 1987; Ohno, 1988). In estimating PPP exchange rates under the present system, the problem we face is one of extracting the hypothetical rate of exchange at which prices of tradable goods would be equalized on average across countries from the noisy data of the 1970s and 1980s when PPP did not generally hold. Note also that there is no single exchange rate which would preserve the law of one price for each individual tradable good under the current exchange arrangement.

1. The "base-year" problem

The problem of estimating PPP exchange rate between (say) Japan and the United States can be summarized as follows. Ideally, we would like to have the absolute yen and dollar prices for the common broad basket of tradable goods whose components are prescribed in appropriate physical quantities: P_a and P_a^*, respectively. Then the absolute PPP exchange rate can be simply computed as:

$$E^{PPP} = \frac{P_a}{P_a^*} \tag{1}$$

Unfortunately, however, there is no such comparable absolute price data among major industrial countries.

In the absence of this information, we could still estimate PPP using the technique of relative PPP. Existing official producer price indices (PPIs) are price relatives such that:

$$E^{PPP} \approx \frac{\theta P}{P^*} \tag{2}$$

where θ is an unknown scale factor that links the price relatives, P and P*. These indices represent domestic currency prices of commodity baskets which are similar in composition but of arbitrary size--for example, 100 in the year 1967 or 1980. The approximate equality ($\approx$) reflects the fact that the two commodity baskets may not have the exactly same weights. With θ unknown, (2) is a correct formula only up to a positive multiplicative factor. The so-called "base-year" problem in estimating PPP is equivalent to that of assigning an appropriate value to θ.

2. The Cassel-Keynes method

In estimating PPP exchange rates after the turbulence of World War I, both Cassel (1922) and Keynes (1923a) solved this problem with a simple method which is still practiced widely today. Their method amounts to choosing a base year ("time 0") when one can reasonably assume that PPP actually held, and then using the subsequent movements of relative prices for updating the base period's exchange rate to get the new estimate of PPP at time t: 1/

$$E_t^{PPP} \approx E_o \cdot \frac{(P_t/P_o)}{(P_t^*/P_o^*)} \qquad (3)$$

where E_o is the actual and PPP exchange rate at time 0, and the θ in equation (2) is $E_o P_o^*/P_o$.

This methodology was well suited for the historical circumstances witnessed by the two economists. Because of unparalleled exchange rate stability and active and largely unrestricted international trade under the gold standard, the presumption that PPP held among principal countries in the early 20th century is a justifiable one (Triffin, 1964; McCloskey and Zecher, 1976). Thus, 1913 was a natural base year from which to project PPP exchange rates after the War of 1914-1918.

However, the Cassel-Keynes method is hardly useful in the last quarter of the 20th century. After a long period of fluctuating exchange rates and constant violation of PPP, there is no single (not-too-distant) base year for which one could confidently assert that PPP held among the yen, dollar, and mark. Various authors have made the case for this or that base year--for instance, 1973 because of the inception of general floating, 1975 because of international convergence of inflation rates, 1978 because the yen was thought to be at the "correct" level reflecting Japan's competitiveness, 1980 because of the roughly balanced U.S. trade in the previous year--but this leads to a distressingly wide dispersion of estimates for what current PPP exchange rates might be.

3. The long-run averaging

One way to circumvent this problem is to use the long-run average of past relative prices, rather than a single base year, as the bench mark for estimating current PPP exchange rates. Assume that, in the long run of a decade or two, the exchange rate is overvalued and undervalued (by the criterion of PPP in tradable goods) with equal probabilities. Although the exchange rate may remain overvalued or undervalued for a few years, such persistent misalignment will, through

1/ "When two currencies have been inflated, the new normal rate of exchange will be equal to the old rate multiplied by the quotient between the degrees of inflation of both countries" (Cassel, 1921, p. 37).

international arbitrage, exert pressure on national price levels to re-establish PPP in several years. Unless one has a reason to believe that deviating movements of the exchange rate from PPP always occur in the same direction, one may assume that the average nominal exchange rate stays close to PPP in the long run.

In Table 1, we report some estimates of PPP yen/dollar and mark/dollar exchange rates for the recent period of 1988:Q2 (our reference point throughout this paper). Although we are interested in PPP in tradable goods (i.e., producer prices), we also list PPP estimates based on other price indices where available.

Table 1. PPP Estimates for 1988:Q2

Method and base period	Index:	Yen/Dollar				Mark/Dollar			
		PPI	ULC	CPI	GNP defl.	PPI	ULC	CPI	GNP defl.
Long-run averaging with base 1975:Q1-1988:Q2		187	204	197	191	2.11	2.25	1.98	2.09
Long-run averaging with base 1980:Q1-1988:Q2		185	205	193	191	2.25	2.39	2.15	2.39
Morrison-Hale method with base 1980, updated using PPI		192	--	--	--	2.48	--	--	--
Price pressure method with the sample period of 1975:Q1-1988:Q2 1/		177	192	--	--	2.09	2.23	--	--

1/ From Section VI.

Note: Indices used are producer prices (PPI), unit labor costs (ULC), consumer prices (CPI), and GNP deflator, all taken from OECD Main Economic Indicators. Exchange rates are from IMF International Financial Statistics. See text for a detailed account of each methodology.

While the question of how far back one should look to calculate long-run averages remains, it is not unreasonable to include the entire years of the recent floating experience, except the period of the first "oil shock" of 1973-74 when the world economy was in transition to a new system. Thus, with the long-run base period of 1975:Q1-1988:Q2 and using producer price indices (PPIs), PPP exchange rates as of 1988:Q2 are estimated to be 187 yen and 2.11 mark against the U.S. dollar.

One potential problem of the long-run averaging method is the bias due to cumulative measurement error. Since each country uses different ways to correct for changing quality and shifting commodity weights, estimated PPP exchange rates may depend on the particular long-run base used. (If there were no bias, any reasonably long-run average should generate similar estimates.) In practice, however, such biases seem small in recent years. Table 1 shows alternative long-run averaging PPP estimates which omit from the base the last five years of the 1970s. Estimates are not dissimilar to the previous ones, especially for yen/dollar. It is also suggested (McKinnon and Ohno, 1989) that biases are much smaller for PPI than for other price indices.

4. The Morrison-Hale method

Based on the methodology of absolute PPP, the OECD estimates PPP exchange rates among major industrial countries every five years (see Section III). However, the price data from which the OECD estimates are derived contain many nontradable components, since the purpose of their computation is international comparison of income and living standards. Morrison and Hale (1987) have devised a clever method of utilizing the absolute local-currency price data collected by the OECD to estimate PPP in tradable goods.

Morrison and Hale re-evaluated the OECD price data with a new set of weights reflecting the trade patterns of the U.S., Japan, West Germany, and the U.K. The new weights are not reported, but statistical processing of the original and new PPP estimates reveals that the authors have eliminated such nontradables as medical care, leisure and education, government consumption, and construction from the original data while increasing the weight attached to machinery, and so on. Using these weights adjusted for "tradability," Morrison and Hale calculated absolute PPP exchange rates for 1980, and updated them using relative PPIs. The resulting PPP estimates were 203 yen and 2.58 mark to the dollar in early 1987. Further updating to the second quarter of 1988 using PPIs yields 192 yen and 2.48 mark to the dollar.

One serious drawback of the Morrison-Hale method is inclusion of net indirect taxes in their price data. Some tradable goods, notably energy-related products, have greatly different tax and tariff structures across countries. Since energy is more heavily taxed in Japan and West Germany than in the U.S., it is likely that the Morrison-Hale estimates are biased upward, and in fact they are higher than other estimates.

5. The ideal method

The ideal method of estimating PPP in tradable goods (though not practiced today) involves constructing a common and well-defined basket of internationally tradable goods which represents the trade patterns of major industrial countries, and expressing its value in currency units of dollar, yen, mark, and so forth. The basket will have similar contents to producer or wholesale price indices, but it will differ from them on two accounts: the size of the basket is precisely determined in the physical quantity of each good, and the basket is identical for all countries. These "international tradable price indices" will be able to provide the starting values for the McKinnon regime. They will also serve as the nominal anchor for monitoring worldwide inflationary or deflationary pressures.

Since such a project demands a considerable amount of time and resources, it is best to be undertaken by either governments or an international organization on a regular basis. Since governments already collect a multitude of individual price data for the purpose of compiling existing price indices, the technical difficulty in constructing the new index should certainly be surmountable.

6. The problem of price dispersion and momentum

A seldom recognized complication in estimating PPP exchange rates under a floating exchange rate system should be noted. One of the frequent criticisms of price-based PPP estimates is that they are tautological--and biased toward the current exchange rate--once commodity arbitrage becomes completely fluid as with auction market goods such as precious metals. However, the reality is much more complex. Since various goods within an economy differ in tradability, relative prices among them change systematically as the nominal exchange rate fluctuates widely. When the dollar is undervalued (by the PPP criterion), for example, primary commodity price indices would lead us to pick the current value of the dollar as the "PPP" exchange rate; those based on producer prices a somewhat higher value; and those based on unit labor costs a higher value yet. Empirically, the dispersion of PPI-based and ULC-based PPP estimates is significant without being overwhelming, as Section VI will show.

Furthermore, when PPP has been violated for a long time, a differential momentum of inflation often develops across countries: an undervaluation of the dollar (for example) tends to accelerate U.S. inflation relative to Japan. One should be discreet in choosing the starting value of a new PPP-based regime lest the economy should overshoot through continuing movements in internal prices and costs. Without directly estimating these biases and momentum in internal prices, a producer-price based PPP estimate could perhaps serve as a reasonable compromise for the target on which the economy could land softly. However, this remains an issue for further study.

V. The Price Pressure Model

In this section we introduce a new empirical model for estimating PPP exchange rates using price relatives--that is, officially published price and cost indices for two countries with arbitrary choices of the base year, which are nonetheless comparable because the contents of the commodity baskets they represent are similar. The price pressure model is particularly suitable for estimating PPP exchange rates in the McKinnon sense, where PPP is defined as that hypothetical exchange rate which would equate the absolute price levels of the same broad basket of tradable goods (manufactured goods in particular) internationally.

Our primary aim is to endow estimation of PPP with a structural content. The price pressure method is a way of systematically estimating the absolute level of PPP from the information contained in the entire sample period, rather than guessing this or that year being a good base year. The structure we impose is relatively a simple one, which could be summarized in two equations: the relative price equation and the relative cost equation. The relative price equation assumes that any deviation from PPP in the McKinnon sense prompts adjustment in the price of tradable goods in both countries which tends to partially (but not completely) offset the initial deviation of the real exchange rate. Implicit in such relative price adjustment is the pricing behavior of profit-maximizing export firms responding to changes in international competitiveness. The relative cost equation in turn assumes that, when such price adjustment occurs, the domestic cost of production responds in the same direction as output prices to ameliorate excess profit or loss of export firms. Behind this is the wage setting behavior of workers which depends on the expected long-run productivity gain as well as the short-run profitability of the firm.

Fundamentally, the price pressure method takes advantage of differential speeds of adjustment to exchange rate shocks in a model with two types of goods: tradable output (mainly manufactured goods) and non-tradable input (mainly labor). When the nominal exchange rate deviates from the PPP level, so that the international law of one price is upset, the price of output adjusts more quickly than the price of input to re-establish PPP. Because of such divergent movements of the prices of output and input, firms experience variation in profitability--excessive profit when the home currency is undervalued and profit squeeze or even loss when the home currency is overvalued (by McKinnon's PPP criterion). Assuredly, this "price pressure" phenomenon is temporary, and PPP will eventually be restored for all goods in the very long run. Our evidence will show, however, that "temporary" price pressure typically lasts several or more years.

The price pressure model adopts the working definition of PPP where the PPP exchange rate is defined to be that path of the exchange rate which on its own would exert no price pressure on the two countries (the price neutrality of the exchange rate). Needless to say, this working definition is directly attributable to McKinnon's concept of PPP.

1. Competitiveness

The model assumes two countries--say, Japan and the United States--producing tradable manufactured goods which are similar but imperfect substitutes to one another. These goods are produced in each country with a single nontradable input (labor) under the assumption of constant returns to scale.

Let us define competitiveness between Japan and the United States in terms of production costs. In other words, we define competitiveness to be the real exchange rate where relative costs of producing manufactured goods are used as the deflator:

$$\sigma_t = e_t + c_t^A - c_t^J \tag{4}$$

where e_t is the log of the nominal yen/dollar rate, and c_t^A and c_t^J are the logs of unit labor costs in America and Japan, respectively. A rise in σ_t associated with an increase in e_t (yen depreciation) or an increased U.S. unit cost tips competitiveness in Japan's favor, while an increase in Japanese cost lowers σ_t and makes U.S. firms relatively more competitive.

Equation (4) defines competitiveness solely in terms of relative costs and independently of firms' pricing behavior given the cost differential. The alternative way to define competitiveness would be to deflate the nominal exchange rate by relative prices of output, rather than relative costs of producing it. However, this method of measuring competitiveness tends to confuse the change in cost advantages due to technology, relative factor costs and exchange rate movements on the one hand, and export firms' pricing behavior in response to these fundamental forces on the other. As will become clear, the distinction between these two causes of export price changes is important in building a structural model of exchange rate fluctuation and resultant price pressure.

2. The relative price equation

Recent theoretical research in export pricing strategy, where imperfect competition prevails and each firm sets rather than takes the price, has emphasized the importance of market structure in determining how much exchange rate changes are passed through to foreign prices. 1/

1/ While most authors agree that pass-through is generally different from unity, underlying reasons for this conclusion differ from one model to another. For example, Knetter (1989), Krugman (1987b), Mann (1986), and Yamawaki (1988) attribute various degrees of pass-through to dissimilar conditions of demand or supply in each country (in static profit-maximization). Baldwin (1988), Baldwin and Krugman (1986), Foster and Baldwin (1986), Dixit (1987, 1988), and Froot and Klemperer (1988) stress the role of hysteresis in dynamic pricing behavior. Daniel (1987), Klein (1988), and Murphy (1988) contend that different shock structures in the macro economy lead to different optimal price responses to the exchange rate signal.

Following Feenstra (1987), let us assume that an oligopolistic export firm is faced with a downward-sloping demand curve denominated in foreign currency and the cost of production denominated in domestic currency. Given foreign income, foreign rival firms' price and domestic wages, Feenstra shows that the simple framework of static profit maximization gives the pricing rule where the pass-through coefficient (i.e., the elasticity of foreign-currency export price with respect to the exchange rate) depends on the elasticity of marginal revenue with respect to price and the slope of the marginal cost curve. More generally, the pass-through coefficient is a function of the shapes of both demand and supply curves denominated in different currencies. It is not necessarily equal to either zero (no pass-through) or one (complete pass-through), but it is normally between these two extreme cases. 1/

Firms' pricing behavior as described above can be represented by a markup over unit labor cost, where the markup rate depends on the competitiveness as defined in equation (4):

$$p_t^J = \alpha^J \sigma_{t-1} + c_t^J + u_{1t}^J \tag{5}$$

$$p_t^A = -\alpha^A \sigma_{t-1} + c_t^A + u_{1t}^A \tag{6}$$

where p_t^J and p_t^A are logs of unit prices of Japanese and American goods, each measured in respective domestic currency. u_{1t}^J and u_{1t}^A are error terms which reflect other factors affecting firms' pricing behavior. These error terms may be serially correlated individually, and mutually correlated contemporaneously. 2/

Firms and workers set output prices and labor wages one period in advance. Thus, the current unit price reflects competitiveness of the previous period and unit cost which is in effect today but was set in the last period.

In equations (5) and (6), α^J and α^A are simply one minus the corresponding pass-through coefficients, and thus normally take values between 0 and 1. These parameters, which in turn depend on various demand and supply parameters, represent firms' pricing strategy with respect to

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1/ The pass-through coefficient could exceed unity in certain special cases. One sufficient condition for this (in Feenstra's model) is that the elasticity of demand is decreasing in price and marginal costs are declining.

2/ However, for simplicity we assume that both error terms are individually AR1 with the same autoregressive coefficients. This assumption permits a simple structure of the error term in relative form, in equation (8). A similar assumption is made for bilateral productivity shocks below.

changes in competitiveness. For example, $\alpha^J = 0$ in equation (5) implies that Japanese firms are pricing their exports to domestic cost irrespective of the exchange rate. In contrast, if $\alpha^J = 1$ we have

$$p_t^J = \sigma_{t-1} + c_t^J + u_{1t}^J$$

$$= e_{t-1} + c_{t-1}^A - c_{t-1}^J + c_t^J + u_{1t}^J$$

In the steady-state where $c^i_t = c^i_{t-1}$ and $e_t = e_{t-1}$,

$$p_t^J = (e_t + c_t^A) + u_{1t}^J$$

That is, Japanese firms are pricing to foreign cost (converted to yen), irrespective of domestic cost of production. This is the closest analogue of the concept of "pricing to market" in our model.

Empirical studies of export pricing behavior suggest that α^J (for Japan) is different either from zero or one, whereas α^A (for the U.S.) is not statistically different from zero for many manufacturing industries. In other words, U.S. firms tend to price to domestic cost while Japanese firms are more sensitive to the exchange rate (Mann, 1986; Krugman 1987b; Baldwin, 1988; Ohno, 1988; Economic Report of the President, 1988).

Furthermore, consider the special case where $\alpha^J + \alpha^A = 1$ and assume again the steady-state where $c^1_t = c^1_{t-1}$ and $e_t = e_{t-1}$. Then, equations (4), (5), and (6) reduce to

$$p_t^J = p_t^A + e_t + u_{1t}^J - u_{1t}^A$$

which implies that PPP holds constantly except for random errors. However, empirical evidence quite convincingly shows (Isard, 1977; Ohno, 1988) that PPP does not hold for manufactured goods under a floating exchange rate system due to sticky prices. Thus, previous empirical evidence suggests $0<\alpha^J<1$, $\alpha^A \approx 0$, and $\alpha^J + \alpha^A <1$.

In the next step, let us denote relative variables, parameters or error terms by the same symbols as original ones but without superscripts:

$$p_t \equiv p_t^J - p_t^A, \qquad c_t \equiv c_t^J - c_t^A$$

$$\alpha \equiv \alpha^J + \alpha^A, \qquad u_{1t} \equiv u_{1t}^J - u_{1t}^A$$

and so on. (Note that α is defined as the sum of α^J and α^A, rather than the difference.) Then, equations (5) and (6) can be rewritten as:

$$p_t - c_t = \alpha\sigma_{t-1} + u_{1t}$$

$$= \alpha\,(e_{t-1} - c_{t-1}) + u_{1t} \tag{7}$$

where we assume the new error term to be serially correlated:

$$u_{1t} = \rho u_{1,t-1} + \varepsilon_{1t} \tag{8}$$

where ε_{1t} is white noise.

Equation (7) in particular says that relative prices (measured in respective domestic currencies) between Japan and the U.S. systematically deviate from the underlying relative costs of production as competitiveness--defined in equation (4)--changes. Suppose, for instance, that Japanese firms become low-cost producers of manufactured goods relative to U.S. firms either because of a change in cost trends or because the yen depreciates against the dollar. Equation (7) predicts that Japanese firms will increase profit margin (or U.S. firms will shave their profit margin) which tends to offset part of the change in competitiveness. As a result, relative prices do not move as much as relative costs when the yen/dollar rate fluctuates.

Thus, the left hand side of equation (7), $p_t - c_t$, shall be called "price pressure" which is exerted by the departure of the exchange rate from PPP in tradable goods.

3. <u>The relative unit labor cost equation</u>

We assume that changes in labor productivity in each country, denoted x_t^J and x_t^A, are characterized by the following equations:

$$x_t^J - x_{t-1}^J = \bar{x}^J + v_t^J \tag{9}$$

$$x_t^A - x_{t-1}^A = \bar{x}^A + v_t^A \tag{10}$$

where $\bar{x}^J$ and $\bar{x}^A$ are constants representing drift, and v_t^J and v_t^A are shocks to labor productivity. We allow these shocks to be correlated across countries, and they may be serially correlated as well. (However, see the previous footnote.) In relative terms, we have, from (9) and (10):

$$x_t - x_{t-1} = \bar{x} + v_t \tag{11}$$

where

$$x_t \equiv x_t^J - x_t^A, \qquad \bar{x} \equiv \bar{x}^J - \bar{x}^A, \qquad v_t \equiv v_t^J - v_t^A$$

and

$$v_t = \psi v_{t-1} + \varepsilon_{2t} \tag{12}$$

where ε_{2t} is white noise.

Next, we have the following assumptions about the evolution of nominal wages. Workers demand a wage increase in each period (which becomes effective in the next period) based on both the competitive position (i.e., profitability) of the firm and expectations of long-run gain in labor productivity:

$$w_t^J - w_{t-1}^J = \omega^J \sigma_{t-1} + \delta^J \bar{x}^J \tag{13}$$

$$w_t^A - w_{t-1}^A = -\omega^A \sigma_{t-1} + \delta^A \bar{x}^A \tag{14}$$

We presume that ω^i are positive, meaning that a higher rise in wages is realized when firms are internationally competitive and therefore profitable; and that δ^i are between zero and one, because workers demand a gradual pay increase reflecting part of--but not necessarily all of--productivity gain that is expected over the long run.

As before, using the notation $w_t = w^J_t - w^A_t$ and so forth, we obtain the relative wage equation corresponding to (13) and (14):

$$w_t - w_{t-1} = \omega\sigma_{t-1} + \delta\bar{x} \tag{15}$$

The change in relative unit labor costs is simply the change in relative wages minus the change in labor productivity. This can be written, from (7), (11), (12), and (15), as:

$$c_t - c_{t-1} \equiv (w_t - w_{t-1}) - (x_t - x_{t-1})$$

$$= \omega\sigma_{t-1} + \delta\bar{x} - \bar{x} - v_t$$

$$= \frac{\omega}{\alpha}(p_{t-1} - c_{t-1} - u_{1,t-1}) - (1 - \delta)\bar{x} - v_t$$

$$\equiv \beta(p_{t-1} - c_{t-1}) + \hat{\gamma} + u_{2t} \qquad (16)$$

where

$$\beta \equiv \frac{\omega}{\alpha},\ \hat{\gamma} \equiv -(1-\delta)\bar{x},\ u_{2t} \equiv -v_t - \frac{\omega}{\alpha}u_{1,t-1}$$

Equation (16) is our unit labor cost equation. β measures the lagged elasticity of relative wages with respect to "price pressure" exerted by the deviation of the exchange rate from PPP.

Equation (16) shall be coupled with equation (7) to form the two key equations in the price pressure method of estimating PPP exchange rates.

4. The empirical adaptation

The price pressure model for PPP estimation requires a few more steps in order to be applicable to actual data. The first remaining step is to express the model in terms of observable price and cost indices.

Recall that officially published price and cost data have arbitrary base periods which causes the "base-year" problem, as discussed in Section IV. In particular,

$$p_t \equiv \ln\theta_1 + \tilde{p}_t, \text{ where } \tilde{p}_t = \ln(\tilde{P}_t^J/\tilde{P}_t^A) \qquad (17)$$

$$c_t \equiv \ln\theta_2 + \tilde{c}_t, \text{ where } \tilde{c}_t = \ln(\tilde{C}_t^J/\tilde{C}_t^A) \qquad (18)$$

where the tilde indicates the use of official price or unit labor cost indices, unadjusted for the necessary but unknown constants--θ_1 and θ_2, respectively. (See equation (2) in Section IV.)

Let us reproduce the two key equations:

The relative price equation:

$$p_t - c_t = \alpha\,(e_{t-1} - c_{t-1}) + u_{1t} \tag{7}$$

The relative unit labor cost equation:

$$c_t - c_{t-1} = \beta\,(p_{t-1} - c_{t-1}) + \hat{\gamma} + u_{2t} \tag{16}$$

Using (17) and (18), these equations can be rewritten so that only observable variables remain:

$$\tilde{p}_t - \tilde{c}_t = (1 - \alpha)\,\ln\theta_2 - \ln\theta_1 + \alpha\,(e_{t-1} - \tilde{c}_{t-1}) + u_{1t} \tag{19}$$

$$\tilde{c}_t - \tilde{c}_{t-1} = \hat{\gamma} + \beta\,(\ln\theta_1 - \ln\theta_2) + \beta\,(\tilde{p}_{t-1} - \tilde{c}_{t-1}) + u_{2t} \tag{20}$$

The next step deals with serial correlation in the error terms. The error terms of these equation have the following structure due to equations (8), (12), and (16):

$$\begin{aligned} u_{1t} &= \rho u_{1,t-1} + \varepsilon_{1t} \\ u_{2t} &= -\beta\, u_{1,t-1} + \psi\beta u_{1,t-2} + \psi u_{2,t-1} - \varepsilon_{2t} \end{aligned} \tag{21}$$

However, we presume that the twice-lagged cross term is sufficiently small and therefore could be safely ignored empirically. Our somewhat simplified assumption about the error terms is thus a first-order VAR:

$$\begin{aligned} u_{1t} &= \rho_{11}\, u_{1,t-1} + \rho_{12}\, u_{2,t-1} + \varepsilon_{1t} \\ u_{2t} &= \rho_{21} u_{1,t-1} + \rho_{22}\, u_{2,t-1} + \varepsilon_{2t} \end{aligned} \tag{22}$$

where we expect ρ_{12} to be insignificantly different from zero.

Finally, let us summarize the model in vector-matrix form. Equations (19), (20), and (22) provide the basis of our estimation.

Let:

$$y_t = (\tilde{p}_t - \tilde{c}_t,\ \tilde{c}_t - \tilde{c}_{t-1})'$$

$$z_t = (1,\ \tilde{e}_{t-1} - \tilde{c}_{t-1},\ \tilde{p}_{t-1} - \tilde{c}_{t-1})'$$

$$u_t = (u_{1t},\ u_{2t})'$$

$$\varepsilon_t = (\varepsilon_{1t},\ \varepsilon_{2t})'$$

$$A = \begin{bmatrix} (1-\alpha)\ \ln\theta_2 - \ln\theta_1 & \alpha & 0 \\ \hat{\gamma} + \beta\ (\ln\theta_1 - \ln\theta_2) & 0 & \beta \end{bmatrix}$$

$$R = \begin{bmatrix} \rho_{11} & \rho_{12} \\ \rho_{21} & \rho_{22} \end{bmatrix}$$

Then we can compactly express the empirical version of the price pressure model as follows (L is the lag operator and I is the identity matrix):

$$y_t = Az_t + u_t,\ \text{where}\ (I-RL)u_t = \varepsilon_t \tag{23}$$

By pre-multiplying this equation by (I-RL) and rearranging, we obtain:

$$y_t = Ry_{t-1} + Az_t - RAz_{t-1} - \varepsilon_t \tag{24}$$

where ε_t is bivariate white noise. This is the system of equations which is actually estimated.

VI. The Empirical Results

We estimate two important bilateral PPP exchange rates--yen/dollar and mark/dollar--using quarterly average data for 1975:Q1-1988:Q2, with 54 observations. Nominal bilateral exchange rates are taken from line rf of IMF's International Financial Statistics whereas producer price indices and unit labor cost indices (seasonally adjusted) are obtained from OECD's Main Economic Indicators. In estimating the mark/dollar PPP exchange rate, Germany replaces Japan in the model presented in the previous section.

The parameter $\hat{\gamma}$, the long-run trend in the relative unit labor costs, is obtained separately by regressing the logarithm of actual relative unit labor costs on a constant and a time trend over the sample period. The estimated value of γ turns out to be -0.0081 for yen/dollar and -0.0042 for mark/dollar. In annualized terms, this implies that Japanese unit labor costs tended to decline 3.3 percent relative to those in the U.S., while German unit labor costs fell 1.7 percent on average relative to those in the U.S. The assumption of linear trends in relative unit labor costs (i.e., no shifts in trend during the sample period) could be problematic. We will review shortly whether this is an acceptable approximation.

The price pressure model, with two key equations compactly expressed in (24), is estimated by the maximum likelihood method with orthogonalized error terms to ensure efficiency. 1/ The results of estimation are reported in Table 2, for yen/dollar, and in Table 3, for mark/dollar.

1. The fit

The overall fit of the model is fairly satisfactory. The corrected R^2 of the relative price equation is quite high for both yen/dollar (0.848) and mark/dollar (0.749). The corrected R^2 of the relative cost equation is not as high for either yen/dollar (0.211) or mark/dollar (0.085). But this is not surprising because the dependent variable in the relative cost equation is the rate of change, rather than the level, of relative unit labor costs (see (20) for instance). The residual terms in the equations (ε's) are very close to bivariate white noise. Our estimation method forces them to be contemporaneously uncorrelated with each other. In addition, the Durbin-Watson and Q statistics both suggest that, for each currency pair, there is no evidence of serious serial correlation in the residual terms. In light of this, our specification of serial correlation in the original error terms seems appropriate. Estimated values of ρ's are all plausible as well.

1/ The LSQ procedure of the TSP statistical package is used.

Table 2. The Price Pressure Method: Yen/Dollar

Parameter	Estimate	t-statistics
α	0.105	4.44 *
β	0.284	2.61 *
$\ln\theta_1$ 1/	5.6188	120.0 *
$\ln\theta_2$ 1/	5.6109	87.7 *
ρ_{11}	0.700	5.12 *
ρ_{12}	-0.406	-1.61
ρ_{21}	-0.058	-0.53
ρ_{22}	0.493	2.36 *

	$\bar{R}^2$	s.e.	D.W.	Q-stat. 2/
Relative price equation	0.848	0.020	1.67	12.7
Relative cost equation	0.211	0.017	1.92	8.4

1/ The estimated value depends on the base year of the original price or cost indices used, in this case 1980 = 100.

2/ Distributed asymptotically as $\chi^2(8)$. The critical value for the 5 percent significance level is 15.5.

Note: The sample period is 1975:Q1-1988:Q2. Indices used are producer prices (PPI) and unit labor costs (ULC) taken from OECD, Main Economic Indicators. The exchange rate is from IMF, International Financial Statistics. The asterisk indicates significance at the 5 percent level.

Table 3. The Price Pressure Method: Mark/Dollar

Parameter	Estimate	t-statistics
α	0.062	3.40 *
β	0.525	2.87 *
$\ln\theta_1$ 1/	0.7637	31.9 *
$\ln\theta_2$ 1/	0.8095	24.6 *
ρ_{11}	0.768	3.29 *
ρ_{12}	-0.082	-0.24
ρ_{21}	-0.378	-1.44
ρ_{22}	0.063	0.21

	$\bar{R}^2$	s.e.	D.W.	Q-stat. 2/
Relative price equation	0.749	0.021	2.00	7.3
Relative cost equation	0.085	0.019	2.10	5.7

1/ The estimated value depends on the base year of the original price or cost indices used, in this case 1980 = 100.

2/ Distributed asymptotically as $\chi^2(8)$. The critical value for the 5 percent significance level is 15.5.

Note: The sample period is 1975:Q1-1988:Q2. Indices used are producer prices (PPI) and unit labor costs (ULC) taken from OECD, Main Economic Indicators. The exchange rate is from IMF, International Financial Statistics. The asterisk indicates significance at the 5 percent level.

More importantly, the price pressure model imposes six nonlinear constraints compared with the unconstrained version of the same model. 1/ Whether these constraints are consistent with the data can be checked by the log-likelihood ratio test. With the test statistics distributed asymptotically as χ^2 with six degrees of freedom, neither the yen/dollar data (11.46) nor the mark/dollar data (9.16) reject these constraints at the significance level of 5 percent. This further confirms that our model is correctly specified.

2. Estimates for α and β

Estimated values of α, which measures the price response of firms to the exchange rate, are positive fractions and statistically significant. In the case of Japan and the U.S., relative prices move to offset 10.5 percent of the initial deviation of the exchange rate from PPP after one quarter. In the case of Germany and the U.S., the corresponding price adjustment is 6.2 percent of the initial divergence. The difference in the price sensitivity to the dollar exchange rate most likely reflects the relative importance of the dollar exchange rate to Japanese trade compared with German trade.

In contrast, German wages are more responsive to price pressure than Japanese wages, as can be seen from the estimated values of β. When output prices deviate from the cost of production (and thus firms are making unusual profit or loss in the short run), the cost of production itself tends to adjust so that excess profit or loss is partially offset. This tendency is more prominent in Germany, where relative cost movement offsets 52.5 percent of such "price pressure" after one quarter, than in Japan where only 28.4 percent of such pressure is relieved.

These values of α and β raise a few interesting points. First, since Japanese prices are more responsive to the exchange rate but Japanese wages are less responsive to the resultant price pressure, compared with Germany, it follows that the profitability of Japanese firms is much more seriously affected by dollar exchange rate fluctuations than that of German firms--provided that variability of the exchange rate is the same. In other words, short-term exchange risks are borne mainly by firms, rather than by workers, in Japan. Second, with these parameter values, the speed of reversion to a new PPP level following an initial shock in the exchange rate is excruciatingly slow. Simple iterative calculation shows that it takes as many as 20 quarters for relative prices to close half of the initial deviation from PPP, regardless of whether it is Japanese prices or German prices that are involved. This evidence supports the well-known hypothesis of sticky prices. It further implies

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1/ Our model estimates eight parameters including those associated with serial correlation. In the unconstrained version, each of the relative price equation and the relative cost equation would have free parameters on a constant, two lagged dependent variables, two concurrent independent variables, and two lagged independent variables--thus fourteen free parameters in all.

that PPP for tradable goods--at any rate for most manufactured goods--is in practice rarely observed under a floating exchange rate regime. McKinnon suggests that slowness of adjustment may be attributed to the great exchange rate uncertainty. If changes were undirectional, one would expect prices and cost to respond more quickly.

3. PPP estimates

$\ln\theta_1$ and $\ln\theta_2$ are the logarithms of the hitherto unknown constant terms which would reveal the absolute level of the PPP exchange rate (see (17) and (18)). $\ln\theta_1$ is associated with PPP measured in terms of actual output price (and thus inclusive of firms' profits), while $\ln\theta_2$ relates to PPP measured in terms of production cost (and thus exclusive of firms' profits). Note that $\ln\theta_1$ and $\ln\theta_2$ are dependent on the base years of price or cost indices used in estimation (in our case, all indices take the value 100 in 1980). Therefore, the estimated $\ln\theta_1$ and $\ln\theta_2$--and their t-statistics--are neither unique nor easily interpreted.[2] They become meaningful when used to compute the estimated paths of PPP exchange rates in absolute yen/dollar or mark/dollar terms. These estimated paths are unique, regardless of the base years of the indices used.

However, the estimated standard errors of $\ln\theta_1$ and $\ln\theta_2$ are independent from the scaling of indices, and provide us with the valuable information about the accuracy of our PPP estimates. The asymptotic standard errors are as follows:

	yen/dollar	mark/dollar
$\ln\theta_1$	0.064	0.033
$\ln\theta_2$	0.047	0.024

For example, the standard error of 0.064 in $\ln\theta_1$ for yen/dollar implies that (applying the two-sigma rule) the chance of the true PPI-based PPP exchange rate lying above or below 12.8 percent of our estimated PPP yen/dollar path is roughly 1 in 20. Notice that mark/dollar PPP

estimates are considerably "sharper" than those for yen/dollar by the factor of two to one. In addition, the estimators of $\ln\theta_1$ and $\ln\theta_2$ are highly correlated. 1/ This is hardly surprising given the methodology we use to estimate them.

Figures 1 and 2 report the final results of PPP estimation graphically. In each figure, the solid line represents the actual yen/dollar or mark/dollar exchange rate. Superimposed on it are the estimated PPP exchange rates: the one based on PPI and the other based on unit labor costs (ULC). The former includes export firms' profits or losses in addition to relative production cost, while the latter reflects only relative production cost and thus is more smooth. Which of these two concepts of PPP one should use is a matter of judgment, and should also depend on the purpose at hand.

It is immediately apparent that the actual exchange rate is far more volatile than the movement of either relative prices or relative costs of production, with the result that PPP holds only momentarily and by chance under a freely floating exchange rate regime. (At such points, "actual" and "PPP" exchange rates cross.) This phenomenon was also evident from the estimated coefficients of α and β. In the long run, however, the actual exchange rate does not diverge indefinitely from the PPP exchange rate of either variety. Indeed, the actual exchange rate needles through the PPP exchange rate for the entire sample period, always coming back to the PPP level from an over- or under-valued position every few years, only to overshoot it in the other direction.

Furthermore, the price pressure model predicts certain relationships among the three exchange rates plotted in each figure. When the actual exchange rate is above PPP (the dollar is overvalued), profits of U.S. firms are squeezed and profits of foreign firms become fatter. This tends to push the PPI-based PPP above the ULC-based PPP. Conversely, when the actual exchange rate is below PPP (the dollar is undervalued), PPI-based PPP is expected to lie below the ULC-based PPP. While lags and serial correlation in the model complicate the matter somewhat, this general rule should apply if the model has empirical validity. And indeed, most of the times and for both currency pairs (especially for yen/dollar), this seems to be the case. The only exception is the earlier period 1975-77 where no such tendency exists for either yen/dollar or mark/dollar exchange rates. This may suggest that our specification of a linear trend in relative unit labor costs may not be appropriate for the mid-1970s--although the assumption seems acceptable for the remainder of the sample period.

1/ From the asymptotic variance-covariance matrix of the estimated parameters, the correlation between $\ln\theta_1$ and $\ln\theta_2$ is estimated to be 0.96 for yen/dollar and 0.86 for mark/dollar.

For the comparison with other methods of PPP estimation, the following tabulation shows the PPP exchange rates for the second quarter of 1988, estimated by the price pressure method:

	yen/dollar	mark/dollar
PPI-based	177	2.09
ULC-based	192	2.23

These are fairly close to the estimates in Table 1. The fact that different methods yield similar estimates of PPP is highly encouraging. Finally, it is observed that, in the second quarter of 1988, the PPI-based PPP exchange rate was lower than the ULC-based PPP exchange rate for both yen/dollar and mark/dollar. This is as it should be, because the dollar was undervalued against both yen and mark in that quarter by the criterion of PPP. The actual exchange rates were 126 yen to the dollar and 1.71 mark to the dollar.

While one may agree or disagree with the policy of targeting nominal exchange rates so as to achieve PPP, one could hardly deny the technical proposition that such PPP exchange rates are estimable with reasonable confidence. As long as we remain clear as to which price indices should be the basis of PPP estimation, estimates derived from different methods tend to coalesce within a margin of a few to several percent.

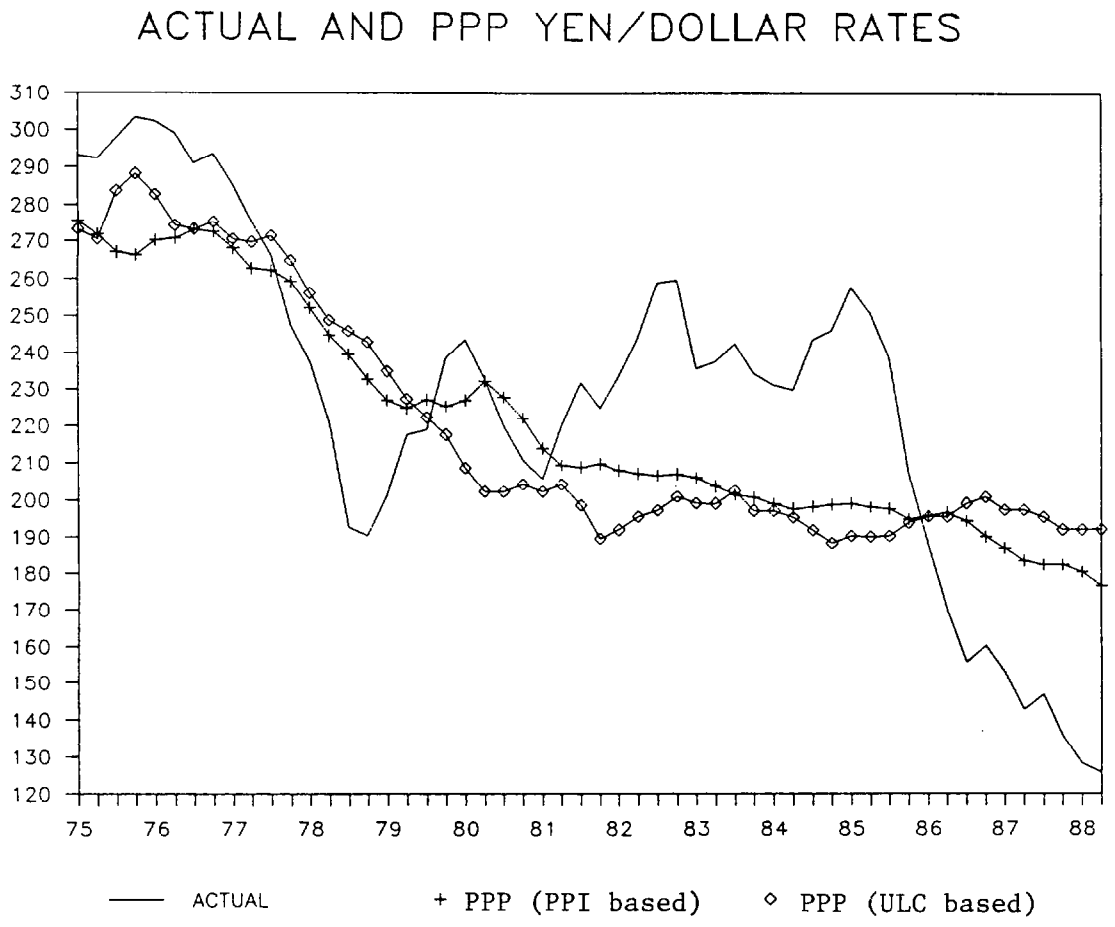
ACTUAL AND PPP YEN/DOLLAR RATES
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
75
76
77
78
79
80
81
82
83
84
85
86
87
88
ACTUAL
+ PPP (PPI based)
◇ PPP (ULC based)

Figure 1.

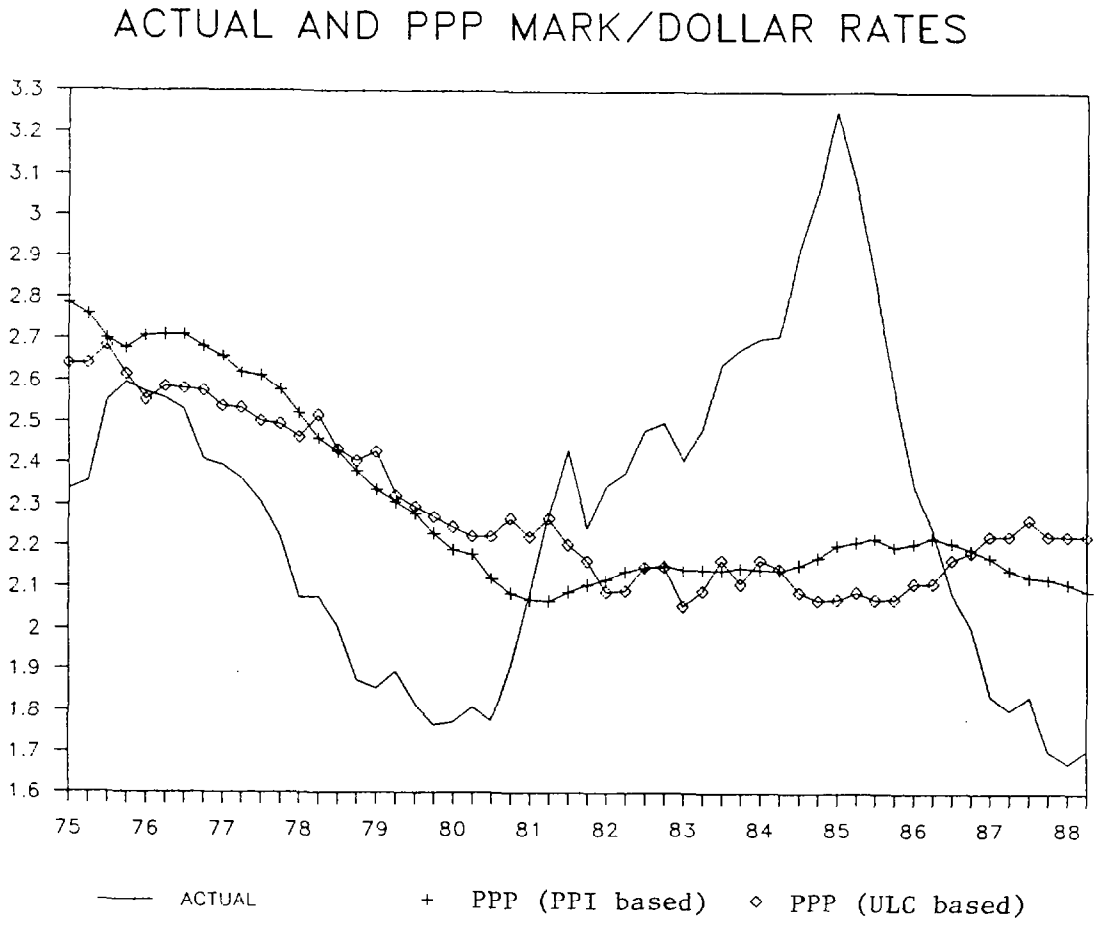
ACTUAL AND PPP MARK/DOLLAR RATES
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
75
76
77
78
79
80
81
82
83
84
85
86
87
88
ACTUAL
+ PPP (PPI based)
◇ PPP (ULC based)

Figure 2.

VII. Concluding Remarks

Purchasing power parity is an old doctrine, dating back to the days of Hume and Ricardo, which still survives and even thrives in the economic literature and policy discussions today. The concept of PPP, the international version of the law of one price, embraces so many important yet diverse facets of open economies that each generation of economists reinterprets it or finds a new meaning to it. We have approached PPP along the path prepared by McKinnon, who regards it as a criterion for conducting monetary and exchange rate policies in an integrated world economy.

This paper has spelled out the particular version of PPP endorsed by McKinnon and contrasted it with other applications of this doctrine. The main contribution of the paper has been the presentation of the price pressure model, where PPP exchange rates are calculated using an entirely new procedure. This is one technical aspect of the McKinnon proposal which has not been formally presented in his own writing. We have shown that estimating PPP, while not a trivial exercise, can be performed with scientific accuracy and hence agnosticism about PPP exchange rates should be dispelled. While this has been but a small step in the grand search for an ideal international monetary system, the importance of the issues involved has made it a worthwhile undertaking.

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