

379  
N81d  
No. 2959

PURCHASING POWER PARITY AND THE  
EFFICIENT MARKETS: THE RECENT  
EMPIRICAL EVIDENCE

DISSERTATION

Presented to the Graduate Council of the  
University of North Texas in Partial  
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Robert P. Yuyuenyongwatana, B.S., M.B.A.

Denton, Texas

December, 1988

2

Yuyuenyongwatana, Robert P., Purchasing Power Parity and the Efficient Markets: The Recent Empirical Evidence.

Doctor of Philosophy (Finance), August, 1988, 75 pp., 14 tables, bibliography, 71 titles.

The purpose of the study is to empirically determine the relevance of PPP theory under the traditional arbitrage and the efficient markets (EPPP) frameworks during the recent floating period of the 1980s.

Monthly data was collected for fifteen industrial nations from January 1980 to December 1986. The models tested included the short-run PPP, the long-run PPP, the EPPP, the EPPP with deviations from expectations, the forward rates as unbiased estimators of future spot rates, the EPPP and the forward rates, and the EPPP with forward rates and lagged values. A generalized regression method called Seemingly Unrelated Regression (SUR) was employed to test the models.

The results support the efficient markets approach to PPP but fail to support the traditional PPP in both the short term and the long term. Moreover, the forward rates are poor and biased predictors of the future spot rates. The random walk hypothesis is generally supported.

## TABLE OF CONTENTS

LIST OF TABLES .....	v
LIST OF NOTATIONS .....	vi
Chapter	
1. INTRODUCTION .....	1
2. LITERATURE REVIEW .....	4
Purchasing Power Parity Theory	
Problems with PPP Theory	
Empirical Issues	
PPP and the Efficient Market	
3. METHODOLOGY .....	27
The Traditional PPP Model	
The Efficient Market PPP	
PPP and the Forward Exchange Rate	
Data	
The Statistical Tests	
4. RESULTS AND DISCUSSION .....	37
The Short-Run PPP Model	
The Long-Run PPP Model	
The EPPP Model	
EPPP with Deviations form Expectations Model	
Forward Rates as Unbiased Estimators of Future Spot Rates Model	

The EPPP and the Forward Rates Model

The EPPP with Forward Rates and Lagged Values  
Model

5. CONCLUSION .....	61
APPENDIX	
A. Relative Purchasing Power Parity .....	64
B. Seemingly Unrelated Regression (SUR) .....	66
C. The Results of Dufour Test .....	67
REFERENCES .....	69

## LIST OF TABLES

Tables		Page
1.	The SUR Estimates of the Short-Run PPP Model (WPI) .....	39
2.	The SUR Estimates of the Short-Run PPP Model (CPI) .....	40
3.	The SUR Estimates of the Long-Run PPP Model (WPI) .....	43
4.	The SUR Estimates of the Long-Run PPP Model (CPI) .....	44
5.	The SUR Estimates of the EPPP Model (WPI) .....	47
6.	The SUR Estimates of the EPPP Model (CPI) .....	48
7.	The SUR Estimates of the EPPP with Deviations from Expect Model (WPI) .....	51
8.	The SUR Estimates of the EPPP with Deviations from Expect Model (CPI) .....	52
9.	The SUR Estimates of the Forward Rates as Unbiased Estimators of Future Spot Rates Model .....	54
10.	The SUR Estimates of the EPPP and the Forward Rates Model (WPI) .....	56
11.	The SUR Estimates of the EPPP and the Forward Rates Model (CPI) .....	57
12.	The SUR Estimates of the EPPP with the Forward Rates and Lagged Values Model (WPI) .....	59
13.	The SUR Estimates of the EPPP with the Forward Rates and Lagged Values Model (CPI) .....	60

## LIST OF NOTATIONS

$F_t$	Forward exchange rate quoted in foreign currency per U.S. dollar at time $t$
$I_t$	Inflation rate of the United States at time $t$ defined as $\ln P_t - \ln P_{t-1}$ , where $t-1$ denotes the preceding period
$I_t^f$	Inflation rate of a foreign country at time $t$ defined as $\ln P_t^f - \ln P_{t-1}^f$
$I_t^\delta$	Inflation rate differential at time $t$ defined as $(\ln P_t - \ln P_{t-1}) - (\ln P_t^f - \ln P_{t-1}^f)$
$L_t$	Price level of the United States at time $t$ (where the occurrence of the subscript 0 denotes the base period)
$L_t^f$	Price level of a foreign country at time $t$
$P_t$	Price index of the United States at time $t$
$P_t^f$	Price index of a foreign country at time $t$
$S_t$	Spot exchange rate quoted as foreign currency per U.S. dollar at time $t$
$\%S_t$	Percentage change in the spot exchange rate from the previous period, $\ln S_t - \ln S_{t-1}$

## CHAPTER 1

### INTRODUCTION

Purchasing Power Parity (PPP) theory describes the behavior of the equilibrium exchange rate in the long run between two nations.<sup>1</sup> There are two basic empirical definitions of PPP doctrine: the absolute and the relative PPP. The absolute version states that the equilibrium exchange rate (the PPP rate) between two countries is determined by the ratio of their internal price levels.<sup>2</sup> The relative version is considerably less restrictive; it defines the movement (the change) of the exchange rate, relative to a given base period, as the difference in the inflation rates of the two countries using the same base period. The base period is ideally the period of equilibrium in which absolute PPP is valid.<sup>3</sup>

---

<sup>1</sup>For excellent reviews of PPP theory, the reader is referred to Officer (1976, 1982).

<sup>2</sup>Internal price level is the aggregate prices of the country's own production of goods and services. Ideally, all imports are excluded (Officer 1976, 7).

<sup>3</sup>Practically, the equilibrium period cannot truly be found. In such case, any "normal" period is sufficient (Officer 1976, 8). A "normal" period is the period during which short-run exchange rates do not significantly depart from those predicted by PPP. Although Officer (1976, 1982) has stressed the importance of a "normal" base period, it should be noted that relative PPP can be derived from the covered interest arbitrage (see APPENDIX) argument, which does not place any emphasis on a "normal" base period requirement.

The traditional arbitrage approach to PPP theory has mixed empirical support. Empirical evidence has suggested that PPP held during the 1920s (Gailliot 1970; Hodgson and Phelps 1975; Hakkio 1984), especially during the German hyperinflation of the early 1920's (Frenkel 1980). However, the behaviour predicted by PPP is not evident during the floating period of the 1970's (Frenkel 1979; Caginalp 1982; Pippenger 1986; Gaab, Granziol, and Horner 1986).

One conclusion from the evidence is that the applicability of PPP is period specific. However, some studies (i.e., Officer 1980; Lothian 1985) show that PPP holds in the long run, leading proponents of PPP (i.e., Cassel 1918; Officer 1976) to argue that PPP should be looked upon as the long-run theory of exchange rate.

Roll (1979) and Frenkel (1979) were among the first to investigate PPP in the context of efficient markets. The rationale of this approach is that all relevant information has already been imputed in the currency price, that is, the exchange rate. This implies that PPP in the efficient markets is applicable in the short run. The evidence, mainly from the 1970's and early 1980's (i.e., Koveos and Seifert 1986; Booth, Duggin, and Koveos 1985) tends to support the efficient market hypothesis.

The problem is whether PPP is still a viable theory to explain the behavior of exchange rates during the recent period of the 1980's. The purpose of this paper is to

empirically determine the relevance of the purchasing power parity (PPP) theory within the traditional arbitrage and the efficient markets frameworks during the recent floating period of the 1980's. The present study is unique because it investigates PPP under both approaches during the more recent period of 1980's.

Four chapters form the main body of the study. Chapter 2 reviews some of the relevant literature pertaining to PPP theory. Chapter 3 describes the methodology. Chapter 4 discusses the results. Chapter 5 presents general conclusions and some suggestions for future research.

## CHAPTER 2

### LITERATURE REVIEW

The chapter is divided into four main sections. Section I provides the background and the five assumptions of PPP used in this study. Section II discusses the problems with the theory: selection of the index number, the difference in productivity in the economies studied, structural changes in the economies being compared, transportation costs and barriers to entry, net unilateral capital movements, and the nonconstancy of ex-ante real interest rates. Section III reviews two empirical issues of PPP: the law of one price and the short-run versus the long-run PPP. Section IV discusses PPP in the context of efficient markets.

#### Purchasing Power Parity Theory

Gustav Cassel (1918) is credited with coining the phrase "purchasing power parity" and developing the theory, although the concept had been recognized long before. Bergstrand (1983) shows that PPP doctrine can be traced to the writing of Martin de Azpilcueta Navarro, a theologian at the School of Salamanca in Spain, in 1556. Officer (1982) adds that the PPP concept also received wide attention by such bullionist writers and economists as Horner, Wheatly,

Foster, Blake, and Ricardo during the Bank Restriction period from 1797 to 1821.<sup>4</sup>

PPP theory typically assumes: (1) no restrictions to nor interventions in currency exchange and trade, (2) no significant information and transportation costs, (3) identical tastes and preferences in goods and services within and across countries, (4) no real changes in the country's economic structure, and (5) constant real interest rates across countries. A corollary to the first assumption is the assumption of no prolonged net unidirectional flow of capital. These five assumptions ensure the existence of efficient commodity arbitrage and/or substitution. Implicit in the arbitrage assumption is the proposition that the relative prices of tradables and nontradables (i.e., services) remain constant within countries (Isard 1978, 4). Furthermore, commodity arbitrage guarantees that the law of one price,<sup>5</sup> which is important to the absolute version of PPP, can be applied on the international level (Bergstrand

---

<sup>4</sup>Officer (1982) gives a detailed history as to the evolution of PPP theory from the ancient Greek and Roman period to modern time.

<sup>5</sup>Officer (1986) defines the law of one price as follows: "The law of one price for tradables states that there is a unique price of a tradable commodity irrespectively of the country of output, where the respective home-currency prices of the commodity are expressed in a common currency via market exchange rate . . . . For the law of one price to be extended from tradables to all commodities one requires the further relationship that, for each country, the price level of tradables is equal to that of nontradables" (160).

1983). The third assumption also guarantees that the countries' general price indices (proxies for general price levels for the same bundle of goods) are comparable. The fourth assumption restricts the responses of exchange rate and price variables to pure monetary changes (no real structural changes in the economy). The fifth assumption (important to relative PPP) ensures that exchange rate movements are attributable to relative price movements between two countries.

### Problems with PPP Theory

#### Selection of Index Number

The assumptions listed above cause many theoretical and/or empirical problems. First, the strong assumption of homogeneity of tastes and preferences, which allows for cross-country comparison of price indices, is questionable. It is very unlikely for people of any two nations to prefer to consume the same bundle of goods. Even if the same bundle of goods is preferred and consumed, different weighing schemes can cause a discrepancy in PPP (Officer 1976, 13-15 and Bergstrand 1983, 18). Therefore, different price indices would give different PPP results. Officer (1978) uses the gross domestic product deflator (GDP) and the consumer price index (CPI) as proxies for price levels to test his models.

His findings suggest that the sample using the "GDP-concept"<sup>6</sup> supports the absolute PPP model, while the sample using the "cost-of-living-concept (using the CPI) supports the model of relative PPP. Frenkel (1976, 180) comments that if one advocates that the PPP concept involves only traded goods, then the wholesale price index (WPI), which is heavily weighed with traded goods, should be used. On the other hand, the use of CPI implies that the PPP concept includes a broad spectrum of goods, including nontradables.

#### Differences in Productivity

Related to the index-number problem is the issue of differences in productivity. If the general price level (index) is disaggregated into tradables and nontradables, then, for the absolute PPP not to be systematically biased, the ratio of nontradable goods to tradable goods (internal price ratios) must remain constant.<sup>7</sup> Balassa (1964) proposes that there is a productivity difference between high-income and low-income countries. Compared to a low-income country, a high-income country generally is more productive technologically and thus production in the traded good sector is more efficient. This advantage is not symmetrically distributed across all industries. However, Balassa contends

---

<sup>6</sup>Officer (1978, 563-564) deems the GDP concept to be broader and, therefore, more applicable to PPP theory than the cost-of-living concept.

<sup>7</sup>The law of one price, strictly applied, requires the ratio to be equal to one (see footnote 5).

that most of the deviations from PPP is attributed to nontradable goods<sup>8</sup> (i.e., consumer services). Even assuming the equality of prices of traded goods across countries (ignoring transport costs and all trade restrictions), the higher wage rate in the high-income country will cause the ratio of nontradables to tradables to be higher than that of low-income country. Since nontradable items are not directly reflected in the balance of payment equilibrium, the price parity calculated from the general price level will tend to give an exchange value for the high-income country that consistently underestimates the true long-run PPP rate. This systematic bias increases as the difference in overall productivity between the countries increases. In other words, arbitrage cannot eliminate price differences among nontradable goods.

Balassa's empirical results support his main contention. He finds a high correlation (about 91%) between "the growth of manufacturing productivity and the ratio of the GNP deflator to the price index for manufactured goods" (394-395). He concludes that the use of general price indices for adjustments in exchange rate is not valid. Balassa's findings indicate that the internal price ratios

---

<sup>8</sup>Price discrepancies between nontradable goods across countries occur because of the difficulty of importing and exporting them (even removing all trade barriers), thus preventing efficient arbitrage. Samuelson (1964) put it best this way: "Patently, I cannot import cheap Italian haircuts, nor can Niagara-Falls honeymoons be exported" (148).

are not constant, which violates the main assertion of PPP.

Officer (1974)<sup>9</sup> states that Balassa ignores the differences in the quality of services (i.e., education and medical) provided in countries with high technology and in those with low technology. He points out countries that have highly developed technology will be more efficient; therefore, there is a greater demand for these services from people travelling from countries with a low level of technology. As the result, contrary to Balassa's claim, PPP will overstate the equilibrium level of the currencies of the countries with highly developed technology.

Furthermore, Officer maintains that Balassa's 1964 study is flawed. He criticizes Balassa's use of GNP, rather than GDP, as the measure of income. More seriously, Officer asserts that Balassa's use of GNP per capita as proxy for productivity level is misleading. He claims that GNP per employment is a better measure. Another criticism is that Balassa fails to correctly test his hypothesis. Officer objects to Balassa's use of official exchange rates because they are not the equilibrium rate, as required by absolute PPP. Balassa's tests, therefore, carry a built-in bias. Officer's results suggest "that the equilibrium exchange rate defined by the unit-factor-cost and purchasing-power-parity

---

<sup>9</sup>Officer investigated Houthakker's (1962) factor-price-equalization theorem, which states that the equilibrium exchange rate is the level which gives international equalization of unit factor costs. He examined eleven OECD countries (with Germany as the standard country) from 1952-1970.

theories are close to identical" (877).<sup>10</sup>

In a later study, Balassa (1974) defends his choice of the variables in his 1964 study. First, he does not believe that the use of GNP instead of GDP resulted in any crucial difference in the findings. Second, his ratio of PPP rate to official exchange rates is an estimate of the equilibrium level. Deviations from these ratios indicate either overvaluations or undervaluations of specific currencies. Third, Balassa maintains that Officer's model, his proxy for productivity, and his interpretations of the results " . . . provides no justification for the absolute purchasing power parity as OFFICER alleges. The result only shows the existence of a broad correspondence between international wage differences and differences in productivity level" (882).

The results of other studies have also been inconclusive. Clague and Tanzi (1972) extended Balassa's theory to include human capital (skill), natural resources (as productive factor), and raw labor (factor endowment as related to per capita income) in a study of nineteen Latin American countries. They found a very small correlation between ratio of PPP to the official exchange rate and income

---

<sup>10</sup>This is a powerful conclusion, for it implies that the law of one price holds for all goods including nontradable goods, such as labor.

per capita.<sup>11</sup> However, their three-factor model yielded a much better result when applied to the same sample used by Balassa in his 1964 study. In other words, their results weaken PPP theory by showing the importance of some independent variables other than price levels.<sup>12</sup> Officer (1976) employed a time series model to investigate the extent of productivity bias and found none, which supports PPP theory. On the other hand, the results of Hsieh's study (1982) support his productivity differential model.<sup>13</sup>

#### Other Problems

Structural changes in the economies, significant transportation costs and barriers to entry, one-way capital movements, and nonconstancy of ex-ante real rates of interest also violate the given assumptions of PPP. Significant violation of any of these assumptions will cause the observed exchange rates to deviate from those of PPP. Empirical investigations of the significances of these factors are few and produce no conclusive results.

---

<sup>11</sup>These variables are the ones used by Balassa in his 1964 study.

<sup>12</sup> However, they conclude: "Conversion of national income estimates at purchasing-power parities instead of at official exchange rates would go a long way toward improving the comparability of per capita income figures of different countries" (15).

<sup>13</sup>He claims that his methodology (instrumental variable estimate method) is superior to that used by Officer (1976), for it eliminates the simultaneity problem between nominal wage and price variables.

Structural changes (real as opposed to monetary) in a nation's economy will result in nonconstant internal price ratios. Real changes in the economy, that is differential growth rates among sectors, produce relative changes in sector prices and result in the weakening of the link between exchange rates and the aggregate price levels. These changes will cause the exchange rate to differ from the PPP rate. Officer (1980) tested relative PPP of fourteen industrial nations during seven subperiods, from 1879 to 1975. He found evidence of structural changes in the economies over the long run. Davutyan and Pippenger (1985) examined the hyperinflation period (1919-1925) and compared it to the 1970's (1972-1979). One of their conclusions states that errors in PPP are dominated by shocks that alter relative prices for nontradables. This suggests that internal price ratios do vary, which implies the existence of structural changes.

However, a high degree of openness in the economy will lessen the effect of structural changes which lead to deviations from PPP. Melvin and Bernstein (1984) found that countries with greater trade diversification are less vulnerable to random shocks affecting individual goods. The weight of the traded goods in the overall price index increases with the degree of openness. Consequently, the broad price indices used in empirical tests suggest that PPP is valid in open economies. The evidence, therefore,

suggests that PPP is more appropriate for some countries than for others. Similarly, Aizenman (1985) shows that the beneficial effects of the uses of relative prices of nontradable goods and aggregate prices of all goods as indicators of wage indexation; monetary and exchange rate policies increase with openness. Openness has a dampening effect on the fluctuation of deviations from PPP.

The assumptions of no transportation cost and no barrier to free trade are unrealistic. Boyce and Llewellyn (1983) suggested that non-tariff barriers contribute about 50 percent to trade distortions alone. Marris (1984) showed that tradability of goods is a matter of degree, the key factor of which is the cost of transport. Recently, Aizenman (1986) developed a model that includes transportation costs as the main variable. He argues that the presence of transportation costs affects the traditional regression methodology and causes the rejection of PPP, even though the goods markets are well arbitrated. The main implication of his study is that the deviations from PPP are the results of the "systematic effects of transportation costs and other costs of goods arbitrage" (26).

In sum, the deviations from PPP can be attributed to the total trading costs, due to either natural or artificial barriers. Laffer (1986) concludes:

For each commodity, there exists a band around some pristine concept of pure purchasing power parity in which the domestic price of a good can move relative to its exchange rate adjusted foreign price without eliciting

repercussions in the form of exports or imports. This band represents the sum total of all trading costs whether natural or induced. Within that band and for that commodity, there will be absolutely no tendency for purchasing power parity to hold.

Different commodities may well have bands of differing widths surrounding their purchasing power parity points. Those commodities whose band are the narrowest are the most tradable. Those with the widest bands are generally the least tradable (7).

Capital movements do affect the equilibrium PPP.

Holmes (1967), Viner (1924), Officer (1974), Yeager (1957) and Cassel (1928) have all stated that persistent capital movements in either direction (inflows and outflows) will cause lasting departures from PPP. Houthakker (1962) concludes that prices of certain nontradables, that is, unit labor costs, influence the net flow of capital. He cites the case of overvaluation of the U.S. dollar in the early 1960's that caused capital outflow in the form of capital investment from the United States to other countries which enjoyed lower unit labor costs.

As to the assumption of constant ex-ante real rate of interest across nations, the empirical evidence is mixed. Saunders and Tress (1984) found that the assumption holds better during a period of no price controls (i.e., the first quarter of 1974 to the fourth quarter of 1980). On the other hand, Mark (1985) offers evidence that rejects the ex-ante real rate of interest across countries. He maintains that the rejection of the ex-ante real interest rate also leads to the rejection of joint validity between uncovered interest

parity and ex-ante PPP.

### Empirical Issues

Most empirical studies in traditional PPP fall into one of the two categories: (1) the validity of the law of one price, and (2) the applicability of PPP in the short run versus the long run. If the law of one price fails, then absolute PPP is not applicable because there is more than one price for an identical good. The empirical evidence for the law of one price is mixed. As to the issue of short run and long run applicability, PPP is meant to be a long-run equilibrium theory of exchange rate. Random error terms, representing temporary deviations from PPP, result from monetary and non-monetary disturbances.<sup>14</sup> Therefore, the significant short-run departure of the observed rate from the PPP rate does not necessarily invalidate the theory. The evidence suggests that short-run PPP is not valid during periods of flexible exchange rates but remains valid during periods of high inflation. Nevertheless, PPP is generally valid in the long run.

### The Law of One Price

Given the assumptions of perfect commodity arbitrage

---

<sup>14</sup>Holmes (1967) suggests that Cassel considered the effects of other determinants, i.e., transports and customs, in the exchange rate equation. However, he stipulated that the relative purchasing power of local currency for domestic goods and services to that of foreign counterparts is the most important variable.

and high elasticities of substitution between goods, the law of one price states that identical tradable goods will have the same prices, exchange rate adjusted, everywhere. The breakdown of this law occurs when the transaction costs, including transports, are significantly high. For example, Morande (1986) found that the deviations from the law of one price in Chile from July 1975 through December 1982 were the result of changes in the costs of domestic distributions.

Daniel (1986a) develops a two-country model which assumes lumpy information costs in a firm's pricing schemes. She shows that the prices of both domestic and imported goods are "sticky," that is, they respond more slowly to "news" than do exchange rates. As a result, unexpected changes in the exchange rate produce deviations from the law of one price.

Closely related effect to the role of "news" on deviations from the law of one price is the question of uncertainty. Daniel (1986b) attributes the deviations from the law of one price to the uncertainty a firm faces in terms of lump-sum cost adjustments to the prices of their product. She maintains that the pricing behavior implied by the law of one price is optimal only if there is no uncertainty and no adjustment costs. When there are adjustment costs, the deviations from the optimum increase as uncertainty increases.

Officer (1986) argues that the conventional empirical

tests of the law of one price rely on approaches which are biased towards the rejections of PPP.<sup>15</sup> His aggregate approach uses the price-index ratio of GDP deflators of tradable (PT) and nontradable (PN) goods.<sup>16</sup> He also constructs the Irving Fisher's ideal index number<sup>17</sup> as a proxy of the PPP rate. The sample included 20 nations with 1975 as the base. The main thrust of the study is to observe the relationships between  $PPP^i/R^i$  and  $\{WT^i+WN^i.(PN^i/PT^i)\}/\{WT^b+WN^b.(PN^b/PT^b)\}$ , where WT and WN denote weights of tradables and nontradables respectively, for countries i and b. He calculated the internal price ratios both domestically and internationally and tested the above relationships. The

---

<sup>15</sup>Officer cites three major weaknesses of the conventional disaggregative methods: (1) failure to capture complex substitutions in production and consumption, (2) too severe on the law of one price due to the existence of various transaction costs, and (3) specification errors.

<sup>16</sup>His tradable goods are derived from the agriculture, hunting, forestry, and fishing sectors; the mining and quarrying sectors; and the manufacturing sector. Nontradable goods are represented by electricity, gas, and water; construction; wholesale and retail trade; restaurants and hotels; transportation, storage, and communication; finance, insurance, real estate, and business services; government services; and other producers and services. All these industries make up the GDP.

<sup>17</sup>Officer (1976) defines Irving Fisher's ideal index-number formula as " . . . to take the geometric mean of the parities calculated alternatively using the one and then the other country's expenditure weights" (15). He also adds that this procedure lessens the biases due to the differences in weighing schemes used in the countries examined since the biases run in the opposite directions. The index is used to compute the PPP rate for signifying the long-run equilibrium exchange rate and for international comparisons of standard of living and GDP (see note 14, p. 15).

results strongly support the law of one price.

Others have investigated the law of one price as it applies to certain "commodities" or groups of commodities with mixed results. Genberg (1975) compares quarterly changes of wholesale prices of six basic commodities in eight different nations. His results suggest that the law of one price prevails for these commodities. On the other hand, some (Isard 1974; Bordo and Choudiri 1976; and Kravis and Lipsey 1977) offer evidence against the law of one price, at least for some narrowly defined commodity groups.

Genberg (1978) suggests two reasons as to why the test of the law of one price will fail. The first reason is the different weighting schemes used in the index and the uses of listed prices rather than the actual transaction prices. Second, the commodities represented in the index are not necessarily the same and therefore are not comparable.

#### Short-Run vs. Long-Run PPP

There is evidence to suggest that PPP is valid in the short run. Officer (1978) investigated absolute and relative versions of PPP for eight countries during 1950-55, 1967-70, and 1950-1970.<sup>18</sup> He concludes that his results support both the absolute ("strong") and the relative ("weak") forms of PPP. Others (Frenkel 1980, 1981; Huang 1984; McDonald 1984; and Aizenman 1984) suggest that short-run PPP applies to

---

<sup>18</sup>See also Selection of Index Number.

economies experiencing high inflations, for example, the German hyperinflation episode during the 1920's, in which monetary disturbances dominated any real shock. However, Junge (1984) extends Frenkel's 1981 study to include Switzerland and finds evidence to refute the validity of PPP in the 1920's,<sup>19</sup> which contradicts Frenkel's findings.

Many studies have found that PPP was not valid during the recent floating-rate period. Frenkel (1979, 1981), Booth et. al (1985), and Adams and Bayer (1986) conclude that the exchange rate during the 1970's followed a random walk.<sup>20</sup> Miller (1984), Junge (1981), and Caginalp (1980) also found that PPP did not apply during this period. Most of these studies ascribe the deviations from PPP to unanticipated disturbances.

The validity of long-run PPP has been supported by numerous studies. Officer (1980) finds a lessening of the deviation from PPP, as measured by the error terms, the longer the time span observed. Gailliot (1970) tested ratios of five-year averages of exchange rates (AER) between 1900-1904 and 1963-1967, and the ratios of WPIs of 1965 and those of 1902 (the base year). The second set of ratios are called

---

<sup>19</sup>His results also fail to support PPP in the 1970's.

<sup>20</sup>Random walk suggests that the deviations, as measured by the error term, from PPP are as likely to increase as decrease in the following periods. For PPP to be valid, the deviations should lessen in the following periods (displaying some serial correlations in the changes of the predictive errors). In other words, the deviations from PPP should eventually approach zero in the long run.

relative inflations, and they involve eight industrial nations with the United States as the standard country. He contends that the relative inflation multiplied by the ratios of AERs should not be significantly differently from unity for the long-run PPP to be true. His results suggest that relative price change is the dominant factor in explaining a change in exchange rate, which supports PPP in the long run. Others (Frenkel 1980; Driskill 1981; Demery 1984; Hakkio 1984; Lothian 1985; and Rush and Husted 1985) also provide evidence that validate long-run PPP.

Nevertheless, a few studies question the validity of long-run PPP. Pippenger (1982) employs autoregressive and spectral analysis techniques to analyze the changes in predictive errors based on national and regional price indices. He studied eight industrial nations during the period from 1900 to 1972. The results indicate that the predictive errors follow a random walk (PPP predicts some serial correlations of the changes of the error terms). Adler and Lehman (1983) independently confirm the random walk phenomenon in the long run for their samples.

#### PPP and the Efficient Market

In the efficient market context, PPP incorporates the assumption of rational expectation. Under this assumption, the financial asset holders possess all currently available information and form expectations concerning future values of the assets. In this framework, deviations from PPP are

imputed to unanticipated events that affect the market. In other words, financial holders collectively revise their expectations upon the receipt of new information and act accordingly, which causes exchange rates to fluctuate.

Once again the results of studies of PPP in efficient markets is mixed. Evidence to support PPP in this framework has been provided by Roll 1979; Frenkel 1979, 1981; Hodgson and Phelps 1975; Rogalski and Vinso 1977; Koveos and Seifert 1985, 1986; and Blejer and Khan 1983. However, Geweke and Feige (1979), Hansen and Hodrick (1980), and Huang (1987) present evidence that fails to support the market efficiency hypothesis.

Roll (1979) first introduced the role of expectation<sup>21</sup> in relation to PPP. According to Roll,

. . . all information relevant for predicting the exchange-adjusted differential inflation rate . . . should be contained in the spot market exchange rate determined in the preceding period. No other variable should add to the predictive performance of this spot rate (140).

In the efficient market setting, the current exchange rate is the best predictor of the future exchange-adjusted difference in inflation rates between two nations. As such, in the short run, there should be no significant serial correlations of the residuals, which implies a random walk condition.

---

<sup>21</sup>Roll stresses the role of speculation rather than arbitrage and emphasizes intertemporal transactions. These transactions involve no physical transfer of commodities. Speculators on one country speculate on changes in commodity prices and changes in exchange rates in the other country.

Roll examined twenty-three nations using monthly observations over twenty years (1957-1976). His results strongly support the efficient form of PPP.

Frenkel (1979, 1981) argues that forward rates fully reflect the expectations concerning future exchange rates. Specifically, a forward rate is an unbiased estimate of the future spot rate. To test this hypothesis, Frenkel regressed the logarithm of the current spot exchange rate on the logarithm of the one-month forward exchange rate prevailing during the previous month. His results confirm the role of the forward rate as an unbiased estimate of a future spot rate. He includes other lagged values of the forward rate and forward premiums and also examines short-run deviations from PPP. His main conclusions are: (1) that the exchange market is efficient in the sense that there is no profitable arbitrage opportunity;<sup>22</sup> (2) that the hypothesis that exchange rates follow a random walk cannot be rejected; and (3) that simple PPP is not valid in the 1970's, but deviations from PPP can be characterized by a first-order autoregressive process.<sup>23</sup> One conclusion that can be drawn from Frenkel's study is that short-run PPP is not valid

---

<sup>22</sup>No profitable arbitrage opportunity means the absence of profitable transaction net of transaction costs. If profitable arbitrage exists, then the market is not efficient.

<sup>23</sup>Frenkel (1979) comments that " . . . the stable AR(1) process implies that there are mechanisms which operate to ensure that in the the long run purchasing power parities are satisfied" (23).

during the 1970's, but in the long-run there is a tendency for exchange rates to move towards PPP rates.

Others have also found empirical support for PPP and market efficiency. Hodgson and Phelps (1975) studied market efficiency during the 1920's by introducing lagged variables into their PPP equation. They found that most of the impact of price-level movement on exchange rates occurs within the first three months and dissipates within a year.

Rogalski and Vinso (1977) investigate the relationships between changes in relative price levels and changes in exchange rates. They examined monthly data of eight industrial nations (with the U.S. as the standard country) during two periods: 1920-1924 and 1953-1957. They conclude that

. . . freely floating foreign exchange markets react immediately or nearly so to changes in relative inflation rates. The finding is consistent with both Purchasing Power Parity (PPP) theory and the efficient market hypothesis (80).

Koveos and Seifert (1985) examined black market exchange rates of ten Latin American countries from April 1973 to March 1983. They used Zellner's (1962) Seemingly Unrelated Regression technique, a multiple regression method which explicitly considers correlations of error terms of separate equations. Their results support the efficient markets version of PPP for black market exchange rates. A Later study by Koveos and Seifert (1986) extends the work of Rogalski and Vinso (1977) and improves on the methodologies

used by Roll (1979) and Koveos and Seifert's 1985 study. They examined the lead-lag relationships between exchange rate movements, differences in inflation rates, exchange rate adjusted differentials, and deviations from PPP. They employed the same data used in their study conducted in 1985. They conclude that their results support the efficient market hypothesis, but generally fail to support PPP and the monetary approach to balance of payment.

Blejer and Khan (1983) explored two questions concerning the efficient market, as applied to the Singapore currency market. The first is the validity of the forward rate as an unbiased predictor of the future spot rate and its implication for market efficiency. The second question deals with the accuracy of the forward rate as the predictor of the future spot rates, especially with regard to the effects of unanticipated events (i.e., changes in interest rate differentials) on exchange rates. Blejer and Khan applied the OLS method to monthly data (Singapore vs. the United States) from June 1976 to September 1981. They conclude that the Singapore market is indeed efficient.

However, there is evidence that does not support the efficient market hypothesis. Geweke and Feige (1979) investigated the efficiency of the single and multi forward markets of seven European countries during the fixed rate (from the third quarter of 1962 to the second quarter of 1967) and the flexible rate (from the third quarter of 1972

to first the quarter of 1977) regime. Changes in realized gains (losses) within a single market should be serially uncorrelated. In the multimarket efficiency framework, there should be no possibility of profitable arbitrage. The results show that the efficient market hypothesis is rejected for the single market and for the joint test of markets during the fixed rate period. During the flexible period, the efficient market hypothesis is rejected for the multimarket joint test. Geweke and Feige also provide the risk-return charts. They conclude that market inefficiency is due to transaction costs during the fixed period and risk aversion during the flexible period.

Hansen and Hodrick (1980) tested the efficient market hypothesis, assuming that the forward rate would have been an unbiased predictor of the future spot rate during the 1920's and the 1970's. Their models characterize the relations between current forward premium and other lagged forward premiums. Their null joint hypothesis calls for the intercepts to be constant and the coefficients of determination of the lagged variables to be zero. They found the coefficients of determination to be significant for many of the exchange rates. They conclude that the foreign exchange markets during these periods were inefficient.

Huang (1987) studied PPP and the efficient market hypothesis based on rational expectation. Using monthly data for eleven industrialized nations from April 1974 to December

1984, Huang tested a variation of the standard regression model,  $y = xb + e$ . He used Instrument Variable and Two-Stage Least Square techniques to reduce problems of simultaneity and heteroskedasticity. Huang rejects the null hypothesis of expected nominal exchange rate changes as unbiased predictors of expected inflation rate differentials, thereby failing to support the rational expectation hypothesis.

## CHAPTER 3

### METHODOLOGY

This chapter is divided into two sections. The first section describes the models and the hypotheses to be tested. The second section discusses the data and the statistical method employed to test the hypotheses.

#### Traditional PPP Model

Purchasing Power Parity (PPP) theory describes the behavior of equilibrium exchange rates in the long run. There are two empirical definitions of PPP: the absolute and the relative PPP. The absolute version states that the equilibrium exchange rate (the PPP rate) between two countries is determined by the ratio of their internal price levels.<sup>24</sup> The relative version defines the change in exchange rates, relative to a given base period, as the difference in the inflation rates of the two countries with the same base period. Since the absolute PPP is highly restrictive, this study uses the relative version.

The relative PPP model is typically expressed as

$$(3.1) \quad S_t/S_0 = (L_t/L_t^f)/(L_0/L_0^f)$$

where  $S_t$  is the nominal exchange rate in foreign price of

---

<sup>24</sup>The equation for absolute PPP is usually written as:  $S_t = L_t/L_t^*$ . See (1) for the explanations of the symbols.

domestic currency at time  $t$ ,  $L_t(f)$  is the price level of the domestic (foreign) country, and subscript 0 denotes the base period.<sup>25</sup> Assuming the law of one price holds for an identical bundle of goods because of commodity arbitrage, Equation 3.1 can be rearranged as

$$(3.2) \quad S_t/S_0 = (L_t/L_0)/(L_t^f/L_0^f) = P_t/P_t^f$$

where  $P_t(f)$  is the price index of the domestic (foreign) country for the identical bundle of goods and weights relative to that of the base period.

However, the above assumption for the price index is unnecessarily restrictive and can cause measurement problem (see Index-Number Problem). Let  $I_t^\delta = I_t - I_t^f$ ; relative PPP can be restated, using the covered interest arbitrage assumption,<sup>26</sup> as

$$(3.3) \quad \%S_t = I_t^\delta$$

where  $\%S_t$  is the percentage change in the exchange rate from the preceding period,  $I_t^\delta$  is the differential of the inflation rates, and  $I_t$  ( $I_t^f$ ) is the domestic (foreign) inflation rate from the same previous period. The law of one price and the base period assumptions are not necessary.

Let a price index be the proxy of an inflation rate and  $\%S_t$  be  $\ln(S_t/S_{t-1})$  at time  $t$  relative to  $t-1$ , the

---

<sup>25</sup>All the above and the following symbols are standard notations used in PPP papers.

<sup>26</sup>The covered interest arbitrage states that the forward exchange premium is the difference in the rates of interest of the two countries. See equation (a) of Appendix A.

regression form of Equation 3.3 to be estimated is

$$(3.4) \quad \ln(S_t/S_{t-1}) = a + b\ln(I_t^\delta) + e_t$$

where  $a$  and  $b$  are the parameters to be estimated and  $e_t$  is the error term. If this simple form of PPP holds, then

$$(3.4a) \quad H(0): a = 0 \text{ and } b = 1$$

This is a "strong" test of PPP. If (4a) is found to be true, then PPP suggests a strong contemporaneous relationship between changes in exchange rate and inflation rate differential. This will mean that short-term PPP is strongly supported during the period under investigation.

Related to Equation (3.4) is the question of whether the introduction of lag variables would improve the explanatory power. This follows in the spirit of research conducted by Hodgson and Phelps (1975). That is, if the null hypothesis in Equation 3.4a is rejected, this does not necessarily invalidate PPP because the theory describes the long-run exchange rate behavior. Therefore, this is a "weak" test of PPP. The lagged variables, if their coefficients are significant, determine the relative speed of adjustments of actual spot rates towards those of PPP rates

Equation 3.5 introduces the lagged variables to account for the adjustments to long-run equilibrium,

$$(3.5) \quad \%S_t = b_0 + b_1\ln(I_t^\delta) + \sum b_{i+1}\%S_{t-i} + u_t$$

where  $\%S_{t-i}$  is the lagged percent changes in exchange rates from period  $i = 1$  to  $n$ . If there is no intertemporal effect, then only the ratio of the two countries' price indices,

relative to the previous period, is the determinant of the change in the spot rates:

$$(3.5a) \quad H(0): \quad b_0 = b_2 = \dots = b_{i+1} = 0 \text{ and } b_1 = 1$$

### Efficient Market PPP

As introduced by Roll (1979), the efficient form of PPP (EPPP) postulates that through intertemporal and spatial speculations in the commodity markets, current exchange rates reflect all available information given at  $t-1$ . Roll's relation is expressed as

$$(3.6) \quad E[\ln S_t - (I_t - I_t^f) | Q_{t-1}] = \ln S_{t-1}$$

where  $E$  is the expectation operator and  $|Q_{t-1}$  means given information,  $Q$ , from the previous period,  $t-1$ .

Roll (1979) explains this equation as follows:

In the parlance of efficient markets theory, all information relevant for predicting the exchange-adjusted differential inflation rate [the variable on the left-hand side of equation 6] should be contained in the spot market exchange rate determined in the preceding period. No other variable should add to the predictive performance of this spot rate (140).

The dominant view is that short-run traditional PPP is not valid, and that short-run deviations from PPP tend to persist (Genberg 1978; Shapiro 1983). The question then is how these deviations behave. Both efficient market and traditional PPP suggest that these deviations will be eliminated in the long run (average deviations will tend towards zero). However, short run deviations from PPP in the traditional context should exhibit some serial correlations. In contrast, deviations from PPP under the efficient markets

hypothesis should be serially uncorrelated (Roll 1979; Adler and Lehmann 1983; Koveos and Seifert 1985; and Pippenger 1986).

To test for serial correlations, Equations 3.7 and 3.8 taken from Roll (1979, 145-146) and Koveos and Seifert (1985, 42) are used. From Equation 3.6, let  $D_t = \ln S_t - (I_t - I_t^f)$ . Equation 3.7 is expressed as follows:

$$(3.7) \quad D_t = b_0 + b_1(\ln S_{t-1}) + \sum b_{i+1}D_{t-i} + v_t$$

The third term on the right hand side represents the lagged values of  $D$  from period  $i$  to  $n$ . If EPPP holds, then there should be no serial correlations,

$$(3.7a) \quad H(0): \quad b_0 = b_2 = \dots = b_{i+1} = 0 \text{ and } b_1 = 1$$

According to Roll, EPPP also indicates that " . . . the deviations in expectations . . . . should be uncorrelated over time" (1979, 146). Equation 3.8 tests this assertion, using  $X$  as the deviation in expectation:

$$(3.8) \quad X_t = b_0 + \sum b_i X_{t-i} + w_t$$

where  $X_t = \ln S_t - \ln S_{t-1} - (I_t - I_t^f)$ , and  $w_t$  is the error term. For EPPP to be valid, none of the coefficients would be different from zero:

$$(3.8a) \quad H(0): \quad b_0 = b_1 = \dots = b_i = 0$$

#### PPP and the Forward Exchange Rate

In this discussion, spot rates are substituted for forward rates as proxies for expectations. As previously discussed, Frenkel (1979, 1980 and 1981) has investigated

extensively the efficiency of the currency markets in the 1920's and the 1970's. He concludes that these markets were efficient in the sense that " . . . the forward exchange rate summarizes the relevant available information concerning the future evolution of the rate" (19). In other words, Frenkel found that the current forward rate,  $F_t$ , is a good proxy of the future spot rate,  $S_{t+1}$ .

The forward rate from the previous period,  $F_{t-1}$ , is also an unbiased estimator of the current spot rate,  $S_t$ .

Hence, if

$$(3.9) \quad F_{t-1} = S_t$$

and if PPP holds, then

$$(3.10) \quad F_{t-1}/S_{t-1} = I_t^\delta$$

Equation 3.10 raises to two empirical issues. The first is to determine the relation between the current exchange rate and the forward rate of the previous period. The regression form of Equation 3.9, based on Frenkel (1979, 16; 1981, 668) is

$$(3.11) \quad \ln S_t = a + b \ln F_{t-1} + e_t$$

The forward rate will be an unbiased estimator of the future spot rate if

$$(3.11a) \quad H(0): a = 0 \text{ and } b = 1.$$

The second issue is the relation between the forward premium,  $F_{t-1}/S_{t-1}$ , and the ratio of the price indices (representing inflation rates) under PPP. To answer this question, I propose the following:

$$(3.12) \quad \ln(F_{t-1}/S_{t-1}) = a + b\ln(I_t^\delta) + z_t$$

If traditional PPP holds, then

$$(3.12a) \quad H(0): a = 0 \text{ and } b_1 = 1$$

Under EPPP there should be no serial correlations.

Lagged variables should not enhance the explanatory power of Equation 12. Adding lagged variables to Equation 12 gives

$$(3.13) \quad \ln(F_{t-1}/S_{t-1}) = b_0 + b_1\ln(I_t^\delta) + \sum b_{i+1}\ln(I_{t-i}^\delta) + z_t.$$

If EPPP holds, then

$$(3.13a) \quad H(0): b_0 = 0 \text{ and } b_1 = 1$$

$$(3.13b) \quad H(0): b_2 = \dots = b_{i+1} = 0$$

### Data

The study uses monthly data from January 1980 to December 1986. Fifteen industrial nations, the United States (designated as the domestic country), Canada, Australia, Japan, Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland and the United Kingdom are included. These countries are typically used in studies of exchange rate determinations, in part because the relevant data is generally available for them.

The Consumer Price Index (CPI) and the Wholesales Price Index (WPI) are the price indices<sup>27</sup> used in this study. International Financial Statistics (IFS) tape is the source

---

<sup>27</sup>The objective of using two different indices is to compare the results obtained using each. The differences in the results will indicate the index-number problem.

of data. According to the IFS, the base year for these indices is 1980.

The IFS tape also provides the end-of-the-month quotations for the spot and the forward exchange rates. All exchange rates are expressed in local currency units per United States dollar.

### The Statistical Tests

The models listed in this study are:

1. The Short-Run PPP Model:  $\ln(S_t/S_{t-1}) = a + b\ln(I_t^\delta) + e_t$ , with  $H(0)$ :  $a = 0$  and  $b = 1$ ;
2. The Long-Run PPP Model:  $\%S_t = b_0 + b_1\ln(I_t^\delta) + \sum b_{i+1}\%S_{t-i} + u_t$ , with  $H(0)$ :  $b_0$  and  $b_{i+1} = 0$ ,  $b_1 = 1$ ;
3. The EPPP Model:  $D_t = b_0 + b_1(\ln S_{t-1}) + \sum b_{i+1}D_{t-i} + v_t$ , with  $H(0)$ :  $b_0$  and  $b_{i+1} = 0$ ,  $b_1 = 1$ ;
4. The EPPP with Deviations from Expectations Model:  $X_t = b_0 + \sum b_i X_{t-i} + w_t$ , with  $H(0)$ :  $b_0$  and  $b_i = 0$ ;
5. Forward Rates as Unbiased Estimators of Future Spot Rates Model:  $\ln S_t = a + b\ln F_{t-1} + e_t$ , with  $H(0)$ :  $a = 0$  and  $b = 1$ ;
6. The EPPP and the Forward Rates Model:  $\ln(F_{t-1}/S_{t-1}) = a + b\ln(I_t^\delta) + z_t$ , with  $H(0)$ :  $a = 0$  and  $b = 1$ ;
7. The EPPP with Forward Rates and Lagged Values Model:  $\ln(F_{t-1}/S_{t-1}) = b_0 + b_1\ln(I_t^\delta) + \sum b_{i+1}\ln(I_{t-i}^\delta) + z_t$ , with  $H(0)$ :  $a$  and  $b_{i+1} = 0$ ,  $b_1 = 1$ .

Zellner's (1962) Seemingly Unrelated Regression (SUR) technique is used to test the hypotheses. According to Koveos and Seifert (1985), SUR provides more efficient estimates of the parameters than the Ordinary Least Square (OLS) equation because error terms from separate OLS-type equations are known to be correlated across samples.<sup>28</sup> They have used SUR on samples of Latin American countries (with the U.S. as the principal country), which are considered as developing nations. No studies have applied this method to samples of industrialized nations.

In order to test for serial correlations, Durbin-Watson's D statistic (1950, 1951) and M test (1970) are applied to the models. The M test is the appropriate procedure to test the models which include lagged dependent variables.<sup>29</sup>

In September 1985, France, Germany, Japan, the U.K. and the U.S. launched a concerted program, known as the Plaza

---

<sup>28</sup>See APPENDIX B.

<sup>29</sup>The presence of lagged dependent variables violate the D statistic's assumption of nonstochastic explanatory variables. Durbin (1970) proposes the M procedure to test for serial correlation with the presence of lagged dependent variables. This procedure can be used for any order of autoregression. The M test involves three steps:

1. Estimate the OLS regression (for model 2) and obtain the residuals,  $u_t$ .

2. Estimate the OLS regression of  $u_t$  on  $u_{t-n}$ ,  $\ln(P_t/P_t^f)$ ,  $\%St_{t-n}$ .

3. Test the coefficients of  $u_{t-n}$  to see whether or not they are significantly different from zero. The rejection of the null hypothesis of nonsignificance indicates serial correlations of the explanatory variables.

Agreement, to lower the dollar relative to other currencies (see Mossberg and Murray 1987). This artificial restraint on the dollar would cause a structural change in the currency markets leading to persistent deviations from PPP. The Dufour (1980) procedure<sup>30</sup> is used to test for structural instability in each country.

. Statistical Analysis System (SAS) is used to analyze the data. The data obtained from the IFS data tape was converted into SAS-readable format. All tests of significance were performed at the 0.05 level.

---

<sup>30</sup>The Dufour test is a modified Chow test with the advantage of not requiring full column rank for the variables. In the test, dummy variables are created for the observations of the explanatory variables. OLS regressions are then applied to the full equations containing the dummy variables. Finally the hypothesis testing involves the joint test of dummy variables to be equal to zero (no structural changes).

## CHAPTER 4

### RESULTS AND DISCUSSIONS

The results of the tests are presented in Table 2 through 14. Each table contains the estimated coefficients for the countries considered, the D statistics or the M tests, the F statistics to test hypotheses concerning several coefficients simultaneously, and the joint F test for the entire system. In addition, Table 3 and 4 include the results of the Dufour structural test. All figures are rounded off to three decimal places.

#### The Short-Run PPP Model

Tables 1 and 2 show the results for the Short-Run PPP Model for the WPI and CPI, respectively. None of the countries' intercepts,  $a$ 's, are significantly different from zero, except in the case of Italy. Except for Australia, the coefficients,  $b$ 's, are clearly significantly different from unity, and the F values are highly significant for the WPI for every nations. The CPI model displays similar results except for Canada. The joint F values for both WPI and CPI are also highly significant. Except for the WPI for Australia, no autocorrelations were detected.

These results strongly suggest that PPP is not valid in the short run. In other words, the monthly exchange rates greatly deviate from the rates predicted by the PPP during the period under investigation. The absence of serial correlations means that the deviations from short-term PPP are random. The evidence for the failure of the short-run PPP has support from Hodgson and Phelps (1975), Caginalp (1980), Junge (1981), and Miller (1984).

Table 1  
The SUR Estimates of the Short-Run PPP Model (WPI)

Model 1: $\ln(S_t/S_{t-1}) = a + b\ln(I_t^\delta) + e_t$ Coefficient*				
Country	a	b	DW	F Statistic
Australia	-0.055	-17.683	2.550*	1.196
Austria	0.005	0.053*	1.196	875.730*
Belgium	0.008	-0.280*	1.954	56.288*
Canada	0.003	0.027*	2.276	12.207*
Denmark	0.006	-0.344*	2.124	115.245*
France	0.007	-0.353*	1.963	62.623*
Germany	0.005	0.109*	1.964	107.369*
Italy	0.101*	-0.087*	1.949	45.114*
Japan	-0.0004	-0.816*	1.976	24.116*
Netherland	0.005	-0.134*	1.973	80.000*
Norway	0.005	-0.315*	1.996	91.201*
Sweden	0.002	-1.510*	2.342	133.216*
Switzerland	0.003	0.068*	1.914	8.972*
U.K.	0.006	-0.098*	2.044	5.104*
Joint F =				93.545*

\* The value is significant at the 0.05 level.

Table 2  
The SUR Estimates of the Short-Run PPP Model (CPI)

Model 1: $\ln(S_t/S_{t-1}) = a + b\ln(I_t^\delta) + e_t$				
Coefficient+				
Country	a	b	DW	F Statistic
Australia**	-	-	-	-
Austria	0.001	0.002*	1.957	851,931.000*
Belgium	0.004	-0.102*	1.939	29.739*
Canada	0.002	0.553	2.294	2.410
Denmark	0.004	0.089*	2.071	80.388*
France	0.005	-0.117*	1.947	13.152*
Germany	0.001	0.192*	1.986	25.476*
Italy	0.007	0.084*	1.896	25.476*
Japan	-0.004	-0.239*	1.843	8.523*
Netherland	0.002	0.038*	1.955	39.327*
Norway	0.004	-0.114*	2.206	33.281*
Sweden	0.005	-0.238*	2.058	15.236*
Switzerland	0.001	-0.814*	1.962	23.853*
U.K.	0.006	0.173*	2.063	5.009*
Joint F = 65,788.300*				

\* The value is significant at the 0.05 level.

\*\* CPI data is not available for Australia.

### The Long-Run PPP Model

Table 3 and 4 show the results for the Long-Run PPP Model for the WPI and the CPI, respectively. The deviations from unity for  $b_1$ 's occur in twelve of the fourteen countries for the WPI and eleven of the thirteen countries for the CPI. However, only in the cases of Italy (WPI) and Canada (CPI) are the  $a$ 's significantly different from zero. Furthermore, the coefficients of the lagged variables are significantly different from zero for the WPI in five countries and for the CPI in two countries.

Except for the U.K. for both the WPI and the CPI and Japan for the CPI, the individual  $F$  values are significant. The joint  $F$  is highly significant for both indices. The results of the  $M$  tests reveal no serial correlations among the variables.

These results, especially in conjunction with those obtained for the Short-Run PPP Model, clearly indicate the lack of contemporaneous conformity between actual spot rates and the PPP rates. Still, the impact of the deviations occurs mostly in the initial month. In other words, it takes less than two months for the exchange rates to adjust to the PPP rates for most countries. However, the absence of serial correlations suggests that the adjustments of the exchange rates are random, confirming the random walk hypothesis. The evidence, therefore, fails to support the long-run PPP.

These findings support those of Pippenger (1982) and Adler and Lehman (1983).

The results of the Dufour tests reveal that for the WPI only Italy and Japan show evidence of structural change after September 1985, when the Plaza Agreement was introduced. For the CPI, only Norway shows evidence of structural change after September 1985. However, the tests indicate no significant results for other nations, which suggests that the Plaza Agreement had no impact on most nations in the sample.

Table 3

## The SUR Estimates of the Long-Run PPP Model (WPI)

$$\text{Model 2: } \pi S_t = b_0 + b_1 \ln(I_t^{\delta}) + \sum b_{i+1} \pi S_{t-i} + u_t$$

Coefficient

Country	b <sub>0</sub>	b <sub>1</sub>	b <sub>2</sub>	b <sub>3</sub>	b <sub>4</sub>	b <sub>5</sub>	b <sub>6</sub>	b <sub>7</sub>	M Test+	F Stat.	Dufour++
Australia	-0.071	-22.127	-0.304	-0.215	-0.137	0.040	0.118	-0.295*	1.034	5.045*	0.011
Austria	0.004	0.054*	0.038	-0.072	0.067	0.061	0.022	-0.008	0.467	108.392*	1.519
Belgium	0.009	-0.169*	0.043	-0.011	0.023	-0.005	-0.017	-0.034	0.392	5.410*	1.451
Canada	0.004	-0.005*	-0.110	-0.166	0.042	-0.230*	0.017	-0.148	0.530	2.969*	0.595
Denmark	0.006	-0.409*	-0.049	-0.082	0.071	0.015	-0.005	-0.005	-0.012	14.432*	1.191
France	0.006	-0.315*	-0.002	-0.055	0.035	0.089	0.042	0.046	0.977	6.965*	-
Germany	0.004	0.068*	0.039	-0.066	0.062	0.051	0.021	0.006	0.784	10.343	1.521
Italy	0.008*	0.129*	0.078	0.004	0.073	0.053	0.114	-0.019	0.216	4.389*	2.067*
Japan	0.004	-2.183*	-0.295*	-0.115	0.096	0.018	-0.133	-0.018	0.586	6.160*	2.396*
Netherlands	0.005	-0.230*	0.079	-0.002	0.008	0.022	0.009	-0.013	1.993	13.654*	1.409
Norway	0.005	-0.363*	-0.048	0.074	0.023	0.043	0.034	0.003	0.802	11.382*	-
Sweden	0.0002	-2.177*	-0.205*	-0.039	0.075	-0.011	0.047	-0.045	1.169	21.598*	1.159
Switzerland	0.004	-0.184*	0.126	-0.144*	0.096	-0.005	-0.141*	-0.010	1.858	4.612*	1.767
U.K.	0.007	0.201	0.008	0.094	0.061	-0.085	-0.004	-0.109	1.420	0.978	0.375
Joint F = 14.351*											

\* The value is significant at the 0.05 level.

+ F values are reported as the results of the M tests.

++ The Dufour value is the F value from testing the dummy variables for the period from September 1985 to November 1986. The detailed results are shown in Table 14 of Appendix C.

Table 4

## The SUR Estimates of the Long-Run PPP Model (CPI)

Model 2: %St = b <sub>0</sub> + b <sub>1</sub> ln(I <sub>t</sub> <sup>δ</sup> ) + Σb <sub>i+1</sub> %St <sub>t-i</sub> + ut											
Country	b <sub>0</sub>	b <sub>1</sub>	b <sub>2</sub>	b <sub>3</sub>	b <sub>4</sub>	b <sub>5</sub>	b <sub>6</sub>	b <sub>7</sub>	M Test+	F Stat.	Dufour++
Australia**	-	-	-	-	-	-	-	-	-	-	-
Austria	0.001	0.002*	0.017	-0.041	0.078	0.082	0.045	0.001	0.204	89,275.5*	1.601
Belgium	0.004	0.134*	0.021	0.016	0.025	0.057	0.018	-0.007	0.175	2.017*	1.482
Canada	0.004*	0.605	-0.038	-0.145	-0.002	-0.260*	-0.011	-0.093	1.038	1.793	0.567
Denmark	0.004	0.139*	-0.052	-0.010	0.060	0.083	0.035	-0.002	0.775	7.987*	1.462
France	0.004	-0.069*	-0.044	-0.052	0.037	0.133*	0.022	0.078	0.115	3.093*	1.081
Germany	0.0003	0.323*	-0.005	-0.644	0.058	0.079	0.053	0.021	0.637	3.502*	1.580
Italy	0.004	0.036*	-0.013	0.023	0.080	0.097	0.149*	0.015	0.122	7.009*	-
Japan	-0.003	-0.262*	0.008	0.013	0.113	0.070	0.019	0.021	0.603	1.689	1.630
Netherland	0.001	-0.076*	0.024	0.005	0.029	0.065	0.039	-0.010	0.449	5.927*	1.480
Norway	0.003	-0.131*	-0.039	0.082	0.013	0.054	0.038	0.042	0.452	4.827*	2.067*
Sweden	0.003	-0.135*	0.034	0.045	0.115	0.119	0.138	-0.033	0.258	2.833*	0.794
Switzerland	0.001	-0.887*	0.062	-0.090	0.100	0.023	-0.077	-0.025	1.061	5.220*	1.782
U.K.	0.006	0.153	0.060	0.067	0.056	0.076	-0.059	-0.115	1.050	1.390	0.476
Joint F = 7,360.165*											

\* The value is significant at the 0.05 level.

\*\* CPI data is not available for Australia.

+ F values are reported as the results of the M tests.

++ The Dufour value is the F value from testing the dummy variables for the period from September 1985 to November 1986. Detailed results are shown in Table 15 of Appendix C.

### The EPPP Model

Table 5 and 6 show the results of the EPPP Model for the WPI and the CPI, respectively. For the WPI, eleven countries have intercepts,  $a$ 's, significantly different from zero. For the CPI, ten countries have intercepts significantly different from zero. On the other hand, for the WPI only France has  $b_1$  significantly different from unity. Using the CPI, the  $b_1$ 's are significantly different from unity for Belgium and Norway. The coefficients of the lagged variables are significant for Australia, Denmark, France, and Norway for the WPI, and for Austria, Belgium, Denmark, Germany, Italy, Norway, and Switzerland for the CPI.

The results of the  $F$  tests are remarkably consistent. Canada, Japan, and the U.K. show nonsignificant  $F$  values for both the WPI and the CPI. All other nations show significant  $F$  values. The joint  $F$ 's are both significant for both the WPI and the CPI. No serial correlations were detected, except for Canada for the CPI.

The results are mixed. They suggest that during this period the use of the current spot rate as the predictor of the future spot rate, adjusted for anticipated inflation, is not efficient in the foreign exchange markets of the industrialized nations used in this study. However, the deviations from EPPP are random. In other words, the deviations follow the random walk as suggested by the EPPP.

The result of the joint  $F$  test is consistent with that found by Koveos and Seifert (1985) for the same model using the black market currencies of their Latin American sample. However, the data from Koveos and Seifert (1985) agrees with the predictions of the model in tests of the individual country. None of their  $F$  tests for the individual countries result in the rejection of the model. This difference in the findings implies that the testings of different samples could lead to different results.

Table 5

The SUR Estimates for the EPPP Model (WPI)

Country	Model 3: $D_t = b_0 + b_1(\ln St_{t-1}) + \sum b_{i+1} D_{t-i} + v_t$									
	Coefficient									
	$b_0$	$b_1$	$b_2$	$b_3$	$b_4$	$b_5$	$b_6$	$b_7$	M Test+	F Stat.
Australia	-0.096	11.806	-11.368	0.138	0.067	0.156	0.080	-0.409*	0.083	7.875*
Austria	0.191*	1.036	-0.011	-0.023	0.073	-0.039	-0.064	-0.038	0.484	3.004*
Belgium	0.212*	0.700	0.371	-0.060	-0.021	-0.018	-0.069	0.045	0.238	4.164*
Canada	0.006	0.705	0.210	0.019	0.119	-0.161	0.058	0.047	1.393	0.533
Denmark	0.138*	0.719	-0.360*	-0.093	0.015	0.017	-0.078	-0.001	0.653	5.711*
France	0.116*	0.463*	0.471*	0.014	0.059	0.043	-0.086	-0.019	0.449	3.852*
Germany	0.066*	0.930	0.097	-0.071	0.086	-0.050	-0.038	-0.022	0.457	3.156*
Italy	0.305*	1.051	0.019	-0.021	-0.022	-0.021	0.045	-0.091	0.307	5.315*
Japan	0.783*	0.727	0.301	-0.107	0.097	-0.033	-0.108	-0.020	0.762	1.268
Netherland	0.069*	1.281	-0.191	-0.062	-0.024	0.00004	-0.066	-0.001	0.933	4.026*
Norway	0.066*	1.096	0.012	0.027	-0.214*	0.111	-0.086	0.025	1.425	2.506*
Sweden	0.082*	0.431	0.627	-0.092	0.043	0.035	-0.021	-0.061	0.466	2.022*
Switzerland	0.057*	0.839	0.293	-0.199	0.146	-0.089	-0.175	0.113	0.347	3.891*
U.K.	-0.002	1.886	-0.871	0.0003	0.131	-0.059	-0.215	0.099	0.529	1.712
									Joint F =	2.161*

\* The value is significant at the 0.05 level.

+ The F values are reported as the results of the M tests.

Table 6

## The SUR Estimates for the EPPP Model (CPI)

Model 3: $D_t = b_0 + b_1(\ln St_{-1}) + \sum b_{i+1} D_{t-i} + v_t$										
Coefficient										
Country	$b_0$	$b_1$	$b_2$	$b_3$	$b_4$	$b_5$	$b_6$	$b_7$	M Test+	F Stat.
Australia**	-	-	-	-	-	-	-	-	-	-
Austria	0.225*	1.263	-0.252	-0.084	0.139*	-0.103	0.061	-0.103*	0.311	5.485
Belgium	0.231*	0.178*	0.878*	-0.106	0.079	-0.057	0.027	-0.058	0.257	6.377*
Canada	0.005	0.867	0.106	-0.207	0.215	-0.069	0.126	-0.038	2.715*	0.829
Denmark	0.148*	0.723	0.265	-0.080	0.153*	-0.050	-0.012	-0.065	0.461	6.507*
France	0.120*	0.483	0.474	-0.039	0.111	0.024	-0.030	-0.080	0.747	5.925*
Germany	0.074*	1.047	-0.035	-0.120	0.162*	-0.060	0.023	-0.109*	0.461	5.528*
Italy	0.380*	0.809	0.156	0.009	0.093	-0.085	0.138	-0.171*	0.379	8.721*
Japan	0.288	1.622	-0.608	0.029	0.075	-0.059	-0.164	0.050	0.661	0.983
Netherland	0.080*	0.815	0.217	-0.061	-0.056	-0.042	0.012	-0.075	0.502	5.257*
Norway	0.112*	1.687*	-0.669*	0.001	-0.004	-0.065	0.027	-0.030	0.699	4.482*
Sweden	0.083*	1.201	-0.145	-0.103	0.137	-0.067	0.029	-0.091	0.571	2.456*
Switzerland	0.063*	0.759	0.374	-0.276*	0.277*	-0.169	-0.108	0.058	0.0420	5.079*
U.K.	-0.016	1.196	-0.212	0.026	0.054	0.046	-0.129	-0.025	0.690	1.805
Joint F = 2.110*										

\* The value is significant at the 0.05 level.

\*\* CPI data is not available for Australia.

### EPPP with Deviations from Expectations Model

The results for EPPP with Deviations from Expectations Model are shown on Tables 7 and 8 for WPI and CPI, respectively. The intercepts are different from zero for seven countries for the WPI and only for Italy for the CPI. With the exceptions of Canada, France, Japan and the U.K., the countries in the sample display significant  $b_1$ 's (one lag) from zero, but only Australia and Switzerland show any significant coefficients beyond one lag for the WPI. In contrast, only Switzerland shows  $b_1$ 's to be significantly different from zero. Significant coefficients for lags greater than one period occur for Austria, Canada, Denmark, Germany, Italy, Switzerland and the U.K. for the CPI.

Eight countries display significant  $F$  values, six using the WPI and two using the CPI. Joint  $F$ 's are significant for the WPI and the CPI. The results of the  $M$  tests reveal no serial correlations, except in the case of Norway for the WPI.

A joint test is a rather severe test because it simultaneously considers all the parameters across all nations under investigation. The results of this test fail to support the model. However, the results for the individual country show that most foreign exchange markets are efficient in the context of this model. The movements of the actual spot rates generally conform to those of the PPP rates (the expected spot rates). The absence of serial

correlations further supports the EPPP in that all the rate adjustments (due to new information) are efficiently made within one period (i.e., one month). In other words, all information is reflected within the exchange rate movements. The main implication of the findings is consistent with that of Roll (1979) and Koveos and Seifert (1985).

Table 7

The SUR Estimates of the EPPP with Deviations from Expect Model (WPI)

Country	Model 4: $X_t = b_0 + \sum b_i X_{t-i} + w_t$						M Test+	F Stat.
	$b_0$	$b_1$	$b_2$	$b_3$	$b_4$	$b_5$	$b_6$	
Australia	0.020	-0.325*	-0.216	-0.098	0.067	0.150	-0.285*	4.891*
Austria	0.005	0.120*	0.007	0.060	0.005	-0.035	-0.116	1.857
Belgium	0.010*	0.190*	0.049	0.005	-0.037	-0.054	-0.077	3.547*
Canada	0.007*	-0.050	-0.067	0.062	-0.201	-0.099	-0.127	1.125
Denmark	0.009*	0.203*	0.028	0.016	0.002	-0.023	-0.033	3.304*
France	0.010*	0.104	0.007	0.037	0.050	0.010	0.046	1.029
Germany	0.005	0.119*	-0.031	0.058	-0.010	-0.019	-0.028	1.439
Italy	0.011*	0.178*	0.049	0.038	-0.004	0.105	-0.009	2.956*
Japan	-0.004	0.100	-0.009	0.052	0.062	-0.064	0.045	0.456
Netherland	0.006	0.174*	0.019	0.006	-0.023	-0.043	-0.033	2.581*
Norway	0.008*	0.152*	0.089	-0.090	0.059	-0.034	0.024	1.622
Sweden	0.010	0.197*	0.035	0.047	0.078	0.070	-0.097	1.416
Switzerland	0.004	0.210*	-0.077	0.085	-0.009	-0.173*	-0.050	3.542*
U.K.	0.011*	0.048	0.047	0.127	0.057	-0.154	-0.189	1.613
Joint F = 1.850*								

\* The value is significant at the 0.05 level.

+ The F values are reported as the results of the M tests.

Table 8  
The SUR Estimates of the EPPP with Deviations from Expect Model (CPI)

Model 4: $X_t = b_0 + \sum b_i X_{t-i} + w_t$ Coefficient									
Country	$b_0$	$b_1$	$b_2$	$b_3$	$b_4$	$b_5$	$b_6$	M Test+	F Stat.
Australia**	-	-	-	-	-	-	-	-	-
Austria	0.002	0.048	-0.32	0.100*	-0.015	0.076	-0.007	0.894	1.512
Belgium	0.006	0.098	0.009	0.073	-0.019	0.034	-0.006	0.445	1.161
Canada	0.007*	-0.033	-0.187	-0.0001	-0.286*	-0.099	-0.167	0.515	2.025
Denmark	0.006	0.040	-0.038	-0.102*	0.029	0.055	-0.018*	0.902	1.363
France	0.007	0.024	-0.043	0.072	0.081	0.069	0.084	0.402	1.572
Germany	0.001	0.058	-0.058	0.101*	0.019	0.074	0.024	0.876	1.902
Italy	0.008*	0.036	0.050	0.106	-0.003	0.168*	0.021	0.971	3.077*
Japan	-0.005	-0.088	0.072	0.131	0.089	-0.074	0.079	0.443	0.988
Netherlands	0.002	0.080	0.141	0.067	0.002	0.042	0.004	0.838	1.242
Norway	0.006	0.012	0.041	0.069	-0.029	0.059	0.024	1.171	0.583
Sweden	0.008	0.079	-0.002	0.168	0.017	0.076	-0.086	0.778	1.029
Switzerland	0.0003	0.166*	-0.123	0.149*	-0.015	-0.097	0.012	1.428	2.536*
U.K.	0.007	0.029	0.067	0.115	0.100	-0.062	-0.203*	0.615	1.560
								Joint F = 1.639*	

\* The value is significant at 0.05 level.

\*\* CPI data is not available for Australia.

Forward Rates as Unbiased Estimators of  
Future Spot Rates Model

Table 9 shows the results of the tests of forward rates as the unbiased estimators of future spot rates. Except for the intercept of the U.K. and the coefficient of Australia's  $b$ , all the countries' intercepts are significantly different from zero and the coefficients are different from unity. Furthermore, the  $F$  values for individual countries, except for Australia, and the joint  $F$  values are highly significant. The  $DW$  tests reveal serial correlations for eight countries.

The results indicate that the forward rates are poor predictors of future spot rates. Moreover, the presence of serial correlations strongly suggests that the forward rates are not unbiased. These findings contradict those of Frenkel (1979, 1981). The existence of serial correlations demonstrates that not all information is contained in the forward rates. The evidence suggests the existence of some forward premiums which explain the discrepancies between the two rates.

Table 9

The SUR Estimates of the Forward Rates as Unbiased  
Estimators of Future Spot Rates Model

Model 5: $\text{LnS}_t = a + b\text{LnF}_{t-1} + e_t$ Coefficient				
Country	a	b	DW	F Statistic
Australia	-0.338*	-0.572	0.533*	2.548
Austria	0.354*	0.881*	1.419*	54.232*
Belgium	0.319*	0.918*	1.621	54.486*
Canada	0.028*	0.875*	1.650	10.145*
Denmark	0.167*	0.923*	1.703	41.851*
France	0.163*	0.919	1.687	65.391*
Germany	0.124*	0.879*	1.507*	60.675*
Italy	0.449*	0.937*	1.546*	37.270*
Japan	0.882*	0.840*	0.900*	10.631*
Netherland	0.118*	0.898*	1.526*	42.360*
Norway	0.159*	0.919*	1.934	54.139*
Sweden	0.088*	0.958*	1.744	13.775*
Switzerland	0.134	0.843	1.259*	42.611*
U.K.	-0.015	0.953*	1.551*	7.535*
				Joint F = 8.114*

\* The value is significant at the 0.05 level.

### The EPPP and the Forward Rates Model

Tables 10 and 11 display the results of the EPPP and the Forward Rates Model for the WPI and the CPI, respectively. The results show the intercepts to be significantly different from zero and the coefficients different from one for most countries using both the WPI and the CPI. Only the parameters for Australia (WPI) conform to the model. Also, serial correlations occur for eleven countries using the WPI and for ten countries using the CPI.

Furthermore, with the exception of Australia (WPI), the  $F$  values for the individual countries and the joint  $F$  values are highly significant. The results clearly indicate that the traditional PPP is not valid in this model. The relationship between the forward premium and the inflation rate differential is not contemporaneous.

Table 10

The SUR Estimates of the EPPP and the Forward Rates  
Model (WPI)

Model 6: $\ln(F_{t-1}/S_{t-1}) = a + b\ln(I_t^\delta) + z_t$				
Coefficient				
Country	a	b	DW	F Statistic
Australia	0.261	-28.500	0.668*	1.628
Austria	-0.011*	0.052*	0.799*	406.963*
Belgium	0.003*	0.129*	0.630*	192.515*
Canada	-0.013*	0.221*	0.402*	77.512*
Denmark	0.005*	0.123*	0.426*	116.905*
France	0.001	-0.086*	0.693*	335.019*
Germany	-0.011*	0.226*	1.860	135.832*
Italy	0.021*	0.325*	1.657	12.956*
Japan	-0.013*	0.221*	0.402*	77.512*
Netherland	-0.009*	0.335*	1.761	18.440*
Norway	0.004*	0.084*	0.238*	154.981*
Sweden	0.001	0.055*	0.630*	235.289*
Switzerland	-0.018*	-0.126*	0.416*	185.077*
U.K.	-0.0009	0.204*	0.636*	29.717*
				Joint F = 115.030*

\* The value is significant at the 0.05 level.

Table 11  
The SUR Estimates of the EPPP and the Forward Rates  
Model (CPI)

Model 6: $\ln(F_{t-1}/S_{t-1}) = a + b\ln(I_t^\delta) + z_t$				
Coefficient				
Country	a	b	DW	F Statistic
Australia**	-	-	-	-
Austria	-0.011*	0.167*	0.776*	74.891*
Belgium	0.003*	-0.060*	0.657*	109.862*
Canada	0.001*	0.023*	0.663*	146.275*
Denmark	0.004*	-0.085*	0.366*	77.584*
France	0.001	-0.084*	0.662*	89.880*
Germany	-0.011*	-0.158*	1.829	174.062*
Italy	0.016*	-0.419*	1.780	35.306*
Japan	-0.012*	-0.006*	0.331*	145.477*
Netherland	-0.009*	0.043*	1.733	12.760*
Norway	0.004*	-0.045*	0.245*	116.777*
Sweden	0.0004	-0.298*	0.630*	404.693*
Switzerland	-0.018*	-0.010*	0.423*	96.863*
U.K.	-0.001	0.016*	0.636*	17.183*
				Joint F = 95.589*

\* The value is significant at the 0.05 level.

\*\* The CPI data for Australia is not available.

### The EPPP with Forward Rates and Lagged Values Model

The results of tests of the EPPP with Forward Rates and Lagged Values Model using the WPI and the CPI are summarized in Tables 12 and 13, respectively. Using the WPI, nine countries have intercepts that are significantly different from zero. Using the CPI, six countries have intercepts that are significantly different from zero. In contrast,  $b_1$  is one only for Australia. The coefficients of the lagged variables are significantly different from zero for eleven countries using the WPI and for seven using the CPI. Japan (CPI) and Norway (WPI) have significant coefficients for more than four lags. The DW statistics show evidence of serial correlations for eleven countries using the WPI and for ten using the CPI.

The results from the F tests for individual countries and the joint F and the presence of serial correlations for most countries clearly indicate that EPPP is not valid in the context of the current model. Past information on price movements has not fully contained in the current price movements. In other words, past information is still useful in explaining the forward premiums, the factor that refutes the EPPP. The values of F's for all countries except Denmark and the joint F values are highly significant, which further confirms the failure of the EPPP.

Table 12

The SUR Estimates of the EPPP with the Forward Rates and Lagged Values Model (WPI)

Model 7: $\ln(F_{t-1}/S_{t-1}) = b_0 + b_1 \ln(I_t^\delta) + \sum b_{i+1} \ln(I_{t-i}^\delta) + z_t$ Coefficient										
Country	b <sub>0</sub>	b <sub>1</sub>	b <sub>2</sub>	b <sub>3</sub>	b <sub>4</sub>	b <sub>5</sub>	b <sub>6</sub>	b <sub>7</sub>	DW	F Statistic
Australia	-0.226	-15.959	-28.741	-14.761	-19.195	-18.296	-70.845*	-27.913	0.643	4.420*
Austria	-0.011*	-0.051*	0.110	0.040	-0.034	-0.111	-0.001	0.044	0.891	46.842*
Belgium	0.003*	0.049*	0.030	0.151	0.066	0.002	-0.281*	-0.150	0.774*	17.853*
Canada	-0.001	-0.287*	-0.200*	-0.253*	-0.154	-0.204	-0.108*	-0.075	0.981*	35.214*
Denmark	0.007*	0.227*	0.142	0.159	0.004	0.079	0.029	0.014	0.428*	9.893*
France	-0.002*	-0.062*	-0.085	-0.176*	-0.016	-0.097	-0.201*	-0.029	0.680*	45.413*
Germany	-0.011*	0.194*	0.156	-0.043	-0.040	-0.157	-0.232*	-0.185*	1.850+	23.921*
Italy	0.014*	0.043*	0.107	0.137	-0.163	-0.306	-0.436*	-0.116	1.614+	7.062*
Japan	-0.013*	0.385*	0.145	-0.068	0.038	-0.167	-0.337*	-0.038	0.492*	10.036*
Netherland	-0.009*	0.220*	-0.283	0.120	0.033	-0.041	-0.131	0.426*	1.812+	3.453*
Norway	-0.0001	-0.028*	-0.204*	-0.117	-0.340*	-0.330*	-0.213*	-0.237*	0.440*	25.193*
Sweden	0.002	0.008*	-0.007	0.074	-0.061	-0.002	0.038	0.029	0.630*	33.766*
Switzerland	-0.017*	-0.155*	0.037	-0.147	-0.205	-0.352*	-0.285*	-0.108	0.426*	35.667*
U.K.	-0.002	0.213*	0.119	-0.077	-0.113	0.117	-0.384*	0.021	0.753*	4.760*
Joint F = 19.008*										

\* The value is significant at the 0.05 level.

+ The DW test result is inconclusive.

Table 13

The SUR Estimates of the EPPP with the Forward Rates and the Lagged Values Model (CPI)

Country	Model 7: $\ln(F_{t-1}/S_{t-1}) = b_0 + b_1 \ln(I_t^\delta) + \sum b_{i+1} \ln(I_{t-i}^\delta) + z_t$									
	Coefficient									
	$b_0$	$b_1$	$b_2$	$b_3$	$b_4$	$b_5$	$b_6$	$b_7$	DW	F Statistic
Australia**	-	-	-	-	-	-	-	-	-	-
Austria	-0.011*	0.089	0.055	-0.049	0.042	-0.285*	-0.037	-0.035	0.818*	9.167*
Belgium	0.001	0.006*	-0.513*	-0.291*	-0.327*	-0.064	0.046	-0.010	0.705*	16.740*
Canada	0.001	0.006*	-0.004	-0.039	0.083	-0.0004	-0.037	-0.128	0.678*	17.855*
Denmark	-7.5E-6	-0.232*	-0.390*	-0.332*	-0.246	-0.204	-0.261	-0.096	0.470*	10.938*
France	-0.001	-0.094*	-0.217	-0.098	-0.211	-0.228	0.228	-0.215	0.567*	14.867*
Germany	-0.011*	-0.168*	-0.096	-0.181	-0.116	-0.115	0.109	0.254*	1.821+	41.827*
Italy	0.011*	-0.517*	-0.019	-0.227	-0.069	-0.253	-0.143	-0.039	1.589+	8.204*
Japan	-0.008*	-0.210*	-0.354*	-0.396*	-0.526*	-0.503*	-0.187*	-0.126	0.633*	37.270*
Netherland	-0.010*	0.290*	-0.742*	0.212	0.410	0.336	-0.121	0.475	1.656+	3.534*
Norway	0.001	-0.065*	-0.299*	-0.248*	-0.117	-0.229	-0.197	-0.076	0.281*	15.802*
Sweden	1.7E-5	-0.330*	-0.028	-0.029	-0.002	-0.045	-0.092	-0.006	0.620*	51.105*
Switzerland	-0.017*	-0.113*	-0.138	-0.162	0.237	-0.155	-0.071	-0.071	0.364*	12.453*
U.K.	-0.002	0.117*	0.070	-0.081	0.238	-0.138	0.040	0.135	0.743*	9.689*
									Joint F = 16.728*	

\* The value is significant at the 0.05 level.

\*\* The CPI data is not available for Australia.

+ The DW test result is inconclusive.

## CHAPTER 5

### CONCLUSION

This study investigates the applicability of the traditional PPP and the PPP in the efficient markets context during the period 1980 to 1986. Seven models are tested under the frameworks of traditional PPP and the EPPP.

The evidence presented fails to support PPP in the traditional arbitrage approach. The results of tests of Short-Run PPP and Long-Run PPP Models suggest that neither short-run nor long-run PPP is a satisfactory theory to explain movements in exchange rates of industrialized nations during the 1980's. The relationship between spot rates and the PPP rates are not contemporaneous, which constitutes additional evidence against the validity of short-run PPP. The evidence against the validity of long-run PPP is the absence of serial correlations. The results suggest that the deviations from the long-run PPP follow random walk, contrary to what long-run PPP theory predicts.

On the other hand, the evidence tends to support the EPPP. The movements of the exchange rates correspond well with the expected movements (the EPPP rates). However, the results suggest that current spot rates do not make good predictors of future spot rates. Nevertheless, the deviations

from PPP are serially uncorrelated, a finding that supports the EPPP.

The contention that forward rates are unbiased predictors of future spot rates is certainly not supported by the evidence. Furthermore, forward rates are also poor predictors of the future spot rates. The deviations from PPP and their correlations through time suggest the existence of some continuously adjusted forward premiums to compensate for any unexpected information, which, in turn, is responsible for maintaining the deviations. In short, the application of forward rates appears to ensure the failure of PPP and EPPP.

The index-number problem is not evident in the samples. The WPI and the CPI generally give similar results. The use of either the WPI or the CPI does not lead to different findings in the tests conducted in this study.

Future research should employ different methodology to further test PPP during this period. During the 1980's drastic fluctuations of the exchange rates occurred, notably with the U.S. dollar. Moreover, this is also the period of attempts by leading industrialized nations to coordinate monetary policies and to stabilize the exchange rates, for example, with the Plaza Agreement<sup>31</sup> (Mossberg and Murray, 1987). This kind of cooperation would cause deviations of the

---

<sup>31</sup>The results of the Dufour structural test reveal no structural change after the Plaza Agreement in September 1985 for the countries in the sample (see the results of the Long-Run PPP Model).

exchange rates from the expected PPP rates. These aspects need to be explored more thoroughly. Finally, different samples, for example, Asian and European countries, should also be compared, especially in the studies of EPPP, to ascertain whether the results are different from those obtained for for western countries.

**APPENDIX A**  
**RELATIVE PURCHASING POWER PARITY**

## APPENDIX A

### RELATIVE PURCHASING POWER PARITY

Relative purchasing power parity can be derived through covered interest rate arbitrage and Fisher's equation.

The covered interest rate arbitrage equation (also known as interest rate parity) is written as,

$$(a) \quad \%S = (F - S)/S = i - i^f$$

where  $F$ ,  $S$ ,  $i(f)$  represent the forward rate at time  $t$ , spot rate at time  $t$ , and the nominal interest rate of domestic (foreign) country at time  $t$ , respectively.

If we let the forward rate be an unbiased estimate of future spot rate,

$$(b) \quad F = S_{t+1}$$

then, through substitution, the left-handed side of (a) is the percent change of spot rate,  $\%S$ .

Next, we introduce Fisher's equation,

$$(c) \quad i = R + I$$

$$(d) \quad \text{and } i^f = R + I^f$$

where  $R$  is the real rate of interest, and the inflation rate of domestic (foreign) country is  $I(f)$ .

Through substitution of  $i$  for (c) and  $I^f$  for (d), respectively, (a) is transformed to

(e)  $\%S = I - I^f$

or the relative PPP equation. As can be seen from the above derivations, the real rate of interest remains constant across countries.

## APPENDIX B

### SEEMINGLY UNRELATED REGRESSION (SUR)

## APPENDIX B

### SEEMINGLY UNRELATED REGRESSION (SUR)

$$\begin{aligned} \text{Given: } \hat{Y} &= \hat{\alpha}_1 + \hat{\beta}_1 X + \epsilon_1, \text{ and} \\ \hat{Z} &= \hat{\alpha}_2 + \hat{\beta}_2 S + \epsilon_2 \end{aligned}$$

In SUR and OLS, the dependent variables (i.e., Y and Z) and the independent variables (i.e., X and S) variables are uncorrelated. However, unlike OLS, the error terms are correlated. In other words,

$$\text{cov}(Y, Z) = 0, \text{ cov}(X, S) = 0, \text{ and } \text{cov}(\epsilon_1, \epsilon_2) \text{ not} = 0.$$

Therefore, a better fit is obtained with SUR for the above cases. For example,

$$\text{var}(\hat{\beta}_1)_{\text{SUR}} < \text{var}(\hat{\beta}_1)_{\text{OLS}},$$

and therefore

$$t_{\text{SUR}} > t_{\text{OLS}}, \text{ where } t = \hat{\beta} / \text{std. dev. of } \hat{\beta}.$$

APPENDIX C  
THE RESULTS OF THE DUFOUR TESTS

Table 14

## The Dufour Estimates of the Long-Run PPP Model (WPI)

Country	Coefficient of the Dummy Variables															F Sta
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	
Australia	-0.053	0.132	0.075	0.008	-0.196	-0.204	-0.073	-0.018	0.105	0.011	-0.013	-0.089	-0.093	-0.090	-0.071	0.011
Austria	-0.064	-0.014	-0.50	-0.029	-0.044	-0.076	0.039	-0.077	0.060	-0.083	-0.042	-0.039	-0.022	0.017	-0.053	1.519
Belgium	-0.075	-0.004	-0.050	-0.023	-0.050	-0.082	0.018	-0.081	0.062	-0.081	-0.037	-0.039	-0.012	0.011	-0.058	1.451
Canada	-0.001	-0.007	0.008	0.006	0.018	-0.001	-0.015	-0.024	-0.001	0.001	-0.007	-0.002	-0.007	-0.004	-0.009	0.595
Denmark	-0.069	-0.015	-0.046	-0.021	-0.045	-0.075	0.026	-0.075	0.057	-0.056	-0.026	-0.051	-0.017	0.011	-0.036	1.191
France	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Germany	-0.060	-0.013	-0.054	-0.027	-0.043	-0.073	0.043	-0.078	0.063	-0.081	-0.042	-0.039	-0.018	0.015	-0.054	1.521
Italy	-0.047	-0.029	-0.050	-0.021	-0.039	-0.078	0.043	-0.064	0.042	-0.080	-0.052	-0.040	-0.010	0.007	-0.042	2.067
Japan	-0.119	0.004	-0.052	-0.014	-0.097	-0.084	-0.037	-0.075	0.021	-0.054	-0.066	-0.031	-0.001	0.053	-0.010	2.396
Netherland	-0.020	-0.013	-0.042	-0.022	-0.040	-0.081	0.031	-0.086	0.057	-0.061	-0.052	-0.029	-0.014	0.020	-0.049	1.409
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sweden	-0.074	-0.017	-0.031	-0.011	-0.042	-0.057	-0.016	-0.034	0.039	-0.020	-0.016	-0.057	-0.015	0.011	-0.011	1.159
Switzerland	-0.084	0.014	-0.050	-0.004	-0.049	-0.085	0.030	-0.089	0.076	-0.106	-0.042	-0.043	-0.006	0.049	-0.055	1.767
U.K.	-0.0003	-0.041	-0.032	0.007	0.020	-0.016	0.002	-0.036	0.029	-0.024	0.020	0.006	-0.003	0.021	-0.037	0.375

\* The value is significant at the 0.05 level.

Table 15

## The Dufour Estimates of the Long-Run PPP Model (CPI)

Country	Coefficient of the Dummy Variables															F Stat
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	
Australia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Austria	-0.065	-0.011	-0.052	-0.030	-0.045	-0.079	0.038	-0.079	0.063	-0.084	-0.041	-0.039	-0.020	0.018	-0.055	1.601
Belgium	-0.069	-0.029	-0.057	-0.034	-0.055	-0.080	0.034	-0.081	0.043	-0.087	-0.045	-0.042	-0.028	0.009	-0.062	1.482
Canada	-0.002	-0.008	0.008	0.006	0.018	0.001	-0.013	-0.23	-0.001	0.001	-0.005	-0.002	-0.010	-0.003	-0.008	0.567
Denmark	-0.058	-0.020	-0.052	-0.028	-0.035	-0.078	0.051	-0.077	0.058	-0.076	-0.038	-0.035	-0.020	0.011	-0.048	1.462
France	-0.061	-0.029	-0.050	-0.033	-0.053	-0.081	0.036	-0.029	0.043	-0.067	-0.053	-0.033	-0.029	-0.011	-0.026	1.081
Germany	-0.062	-0.010	-0.052	-0.025	-0.044	-0.075	0.043	-0.075	0.065	-0.083	-0.043	-0.042	-0.019	0.017	-0.053	1.580
Italy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Japan	-0.103	-0.020	-0.059	0.002	-0.069	-0.055	-0.026	-0.078	0.177	-0.049	-0.062	-0.010	-0.019	0.040	0.001	1.630
Netherland	-0.041	-0.018	-0.052	-0.032	-0.042	-0.069	0.048	-0.067	0.056	-0.078	-0.065	-0.024	-0.016	0.029	-0.051	1.480
Norway	-0.043	-0.019	-0.040	-0.003	-0.031	-0.070	0.042	-0.063	0.107	-0.051	-0.027	-0.020	-0.003	0.010	0.0004	2.067
Sweden	-0.055	-0.029	-0.041	-0.012	-0.040	-0.054	0.006	-0.060	0.036	-0.041	-0.025	-0.034	-0.009	-0.001	-0.019	0.794
Switzerland	-0.080	0.014	-0.047	-0.007	-0.049	-0.078	0.036	-0.086	0.072	-0.107	-0.045	-0.040	-0.010	0.049	-0.057	1.782
U.K.	-0.024	-0.039	-0.031	0.003	-0.002	-0.033	-0.018	-0.041	0.025	-0.029	0.011	0.0001	-0.004	0.023	-0.053	0.476

\* The value is significant at the 0.05 level.

## REFERENCES

- Adams, Charles and Russel S. Bayer. "Efficiency and a Simple Model of Exchange-Rate Determination." Journal of International Money and Finance 5 (September 1986): 285-302.
- Adler, Michael and Bruce Lehman. "Deviations from Purchasing Power Parity in the Long Run." Journal of Finance 38 (December 1983): 1471-1487.
- Aizenman, Joshua. "Modeling Deviations from Purchasing Power Parity (PPP)." International Economic Review 25 (February 1984): 175-191.
- \_\_\_\_\_. "Openness, Relative Prices, and Macro-Policies." Journal of International Money and Finance 4 (March 1985): 5-17
- \_\_\_\_\_. "Testing Deviations from Purchasing Power Parity." Journal of International Money and Finance 5 (March 1986): 25-35.
- Balassa, Bela. "The Purchasing Power Parity Doctrine: A Reappraisal." Journal of Political Economy 72 (December 1964): 584-596.
- \_\_\_\_\_. "Purchasing Power Parity and Factor Price Equalization: Comment." Kyklos 27 (Fasc.4, 1974): 879-883.
- Bergstrand, Jeffrey H. "Selected Views of Exchange Rate Determination After a Decade of 'floating'." New England Economic Review (May/June 1983): 14-29.
- Blejer, Mario I. and Mohsin S. Khan. "The Foreign Exchange Market in a Highly-Open Developing Economy." Journal of Development Economics 12 (February/April 1983): 237-249.
- Booth, G. Geoffrey, James E. Duggan and Peter E. Koveos. "Deviations from Purchasing Power Parity, Relative Inflation, and Exchange Rates: The Recent Experience." Financial Review 20 (May 1985): 195-218.

- Bordo, Michael and Ehsan Choudhri. "The Behavior of the Prices of Traded and Non-Traded Goods: The Canadian Case, 1962-1974." Unpublished paper, Carlton University, 1976.
- Boyce, Patricia and Hayden Llewellyn. World Trade Distortions: A Study in Modern Trade Practice. Melbourne, Victoria, Australia: Australian Industries Development Association, 1983.
- Cassel, Gustav. "Abnormal Deviations in International Exchanges." Economic Journal 28 (December 1918): 413-415.
- \_\_\_\_\_. Foreign Investments. Chicago: University of Chicago Press, 1928.
- Caginalp, Oguz A. "Inflation Differentials and Exchange Rates." Nebraska Journal of Economics and Business 21 (Autumn 1982): 19-31.
- Clague, Christopher and Vito Tanzi. "Human Capital, Natural Resources and the Purchasing-Power Parity Doctrine: Some Empirical Results." Economia Internazionale 25 (February 1972): 3-17.
- Daniel, Betty C.. "Real and Nominal Shocks in a Two-Country Price-Setting World." Journal of International Economics 20 (May 1986a): 269-289.
- \_\_\_\_\_. "Optimal Purchasing Power Parity Deviation." International Economic Review 27 (June 1986b): 483-511.
- Demery, D. "Exchange Rate Dynamics: The Swiss/U.S. Case." European Economic Review 24 (March 1984): 151-159.
- Driskill, Robert A. "Exchange-Rate Dynamics: An Empirical Investigation." Journal of Political Economy 89 (April 1981): 357-371.
- Dufour, Jean-Marie. "Dummy Variables and Predictive Tests for Structural Change." Economics Letters 6 (1980): 241-247.
- Durbin, J. "Testing for Serial Correlation in Least Squares Regression When Some of the Regressors are Lagged dependent Variables." Econometrica 38 (May 1970): 410-421.
- \_\_\_\_\_. and G. S. Watson. "Testing for Serial Correlation in Least Squares Regression." Biometrika 37 (1950): 409-428.

- \_\_\_\_\_. "Testing for Serial Correlation in Least Squares Regression." Biometrika 38 (1951): 159-178.
- Frenkel, Jacob A. "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence." Scandinavian Journal of Economics 78 (May 1976): 200-224.
- \_\_\_\_\_. "Efficiency and Volatility of Exchange Rates and Prices in the 1970's." Columbia Journal of World Business 14 (Winter 1979): 15-27.
- \_\_\_\_\_. "Exchange Rates, Prices, and Money: Lesson from the 1920's." American Economic Review 70 (May 1980): 235-242.
- \_\_\_\_\_. "Flexible Exchange Rate, Prices, and the Role of 'News': Lesson from the 1970's." Journal of Political Economy 89 (May 1981): 65-705.
- \_\_\_\_\_. "The Collapse of Purchasing Power Parities During the 1970's." European Economic Review 15 (May 1981): 145-165.
- Gailliot, Henry J. "Purchasing Power Parity As an Explanation of Long-Term Changes in Exchange Rates." Journal of Money, Credit and Banking 2 (August 1970): 348-357.
- Genberg, Hans. World Inflation and the Small Open Economy. Stockholm, Sweden: Swedish Industrial Publications, 1975.
- \_\_\_\_\_. "Policy Autonomy of Small Countries." In Proceedings of a Conference Held by the International Economic Association at Saltsjobaden, Sweden. London: Macmillan, 1977, 183-208.
- \_\_\_\_\_. "Purchasing Power Parity under Fixed and Flexible Exchange Rates." Journal of International Economics 8 (May 1978): 247-276.
- Geweke, John and Edgar Feige. "Some Joint Tests of the Efficiency of Markets for Forward Foreign Exchange." The Review of Economics and Statistics 61 (August 1979): 334-341.
- Hakkio, Craig S. "A Re-Examination of Purchasing Power Parity: A Multi-Country and Multi-Period Study." Journal of International Economics 17 (November 1984): 265-277.

- Hansen, Lars Peter and Robert J. Hodrick. "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis." Journal of Political Economy 88 (October 1980): 829-853.
- Hodgson, John S. and Patricia Phelps. "The Distributed Impact of Price Level Variation on Floating Exchange Rates." Review of Economics and Statistics 57 (February 1975): 58-64.
- Holmes, James M. "The Purchasing Power Parity Theory: In Defense of Gustav Cassel as a Modern Theorist." Journal of Political Economy 75 (October 1967): 686-695.
- Houthakker, Hendrick S. "Should We Devalue the Dollar?" Challenge (October 1962): 10-12.
- Hsieh, David A. "The Determination of the Real Exchange Rate." Journal of International Economics 12 (May 1982): 355-362.
- Huang, Roger D. "Exchange Rate and Relative Monetary Expansions: The Case of Simultaneous Hyperinflation and Rational Expectations." European Economic Review 24 (March 1984): 189-195.
- \_\_\_\_\_. "Expectations of Exchange Rates and Differential Inflation Rates: Further Evidence on Purchasing Power Parity in Efficient Markets." Journal of Finance 42 (March 1987): 69-79.
- Isard Peter. The Price Effects of Exchange Rate Changes: Some Evidence from Industry Data for the United States, Germany and Japan, 1968-1973. Monograph International Finance Division, Federal Reserve Board, March 1974
- \_\_\_\_\_. Exchange-Rate Determination: A Survey of Popular Views and Recent Models. Princeton Studies in International Finance No. 42, 1978.
- Junge, Georg. "Purchasing Power Parity in the 1920s and the 1970s." European Economic Review 26 (October/November 1984): 73-82.
- Koveos, Peter and Bruce Seifert. "Purchasing Power Parity and Black Markets." Financial Management 14 (Autumn 1985): 40-66.
- \_\_\_\_\_. "Market Efficiency, Purchasing Power Parity, and Black Markets." Weltwirtschaftliches Archive (No. 2, 1986): 313-326.

- Kravis, Irving and Robert Lipsey. "Export Prices and the Transmission of Inflation." American Economic Review 67 (February 1977): 155-163.
- Laffer, Arthur B. "Minding Our P's and Q's." The International Trade Journal 1 (Fall 1986): 1-26.
- Lothian, James R. "Equilibrium Relationships Between Money and Other Economic Variables." American Economic Review 75 (September 1985): 828-835.
- Mark, Nelson C. "A Note on International Real Interest Rate Differential." Review of Economics and Statistics 67 (November 1985): 681-684.
- Marris, Robin. "Comparing the Incomes of Nations: A Critique of the International Comparison Project." Journal of Economic Literature 22 (March 1984): 40-57.
- McDonald, Ronald. "The Monetary Approach to the Exchange Rate and the 1920s' Experience with Floating Exchange Rates." Journal of Economic Studies 11 (No. 3, 1984): 14-25.
- Melvin, Michael and David Bernstein. "Trade Concentration, Openness, and Deviations from Purchasing Power Parity." Journal of International Money and Finance 3 (December 1984): 369-376.
- Miller, Stephen. "Purchasing Power Parity and Relative Price Variability: Evidence from the 1970s." European Economic Review 26 (December 1984): 353-367.
- Morande, Felipe G. "Domestic Prices of Importable Goods in Chile and the Law of One Price: 1975-1982." Journal of Development Economics (April 1986): 131-147.
- Officer, Lawrence H. "Purchasing Power Parity and Factor Price Equalization." Kyklos 27 (Fasc.4, 1974): 868-878.
- \_\_\_\_\_. "The Purchasing Power Parity Theory of Exchange Rate: A Review Article." IMF Staff Paper 23 (March 1976): 1-60.
- \_\_\_\_\_. "The Relationship between Absolute and Relative Purchasing Power Parity." Review of Economics and Statistics 60 (November 1978): 562-568.
- \_\_\_\_\_. "Effective Exchange Rates and Price ratios Over the Long Run: a Test of the Purchasing Power Parity Theory." Canadian Journal of Economics 13 (May 1980): 206-230.

- \_\_\_\_\_. Purchasing Power Parity and Exchange Rates: Theory Evidence and Relevance. Greenwich, Connecticut: JAI Press Inc., 1982.
- \_\_\_\_\_. "The Law of One Price Cannot Be Rejected: Two Tests Based on the Tradable/Nontradable Price Ratio." Journal of Macroeconomics 8 (Spring 1986): 159-182.
- Rogalski, Richard J. and Joseph D. Vinso. "Price Level Variations as Predictors of Flexible Exchange Rate." Journal of International Business Studies 8 (Spring/Summer 1977): 71-81.
- Roll, Richard. "Violations of Purchasing Power Parity and Their Implications for Efficient International Commodity Markets." In International Finance and Trade, ed. M. Sarnat and G. P. Szego, 133-179. Cambridge: Ballinger Publishing Company, 1979.
- Rush, Mark and Steven Husted. "Purchasing Power Parity in the Long Run." Canadian Journal of Economics (February 1985): 137-145.
- Samuelson, Paul A. "Theoretical Notes on Trade Problems" Review of Economics and Statistics 46 (May 1964): 145-154.
- Saunders, Anthony and Richard B. Tress. "On the Constancy of the International Real Rate of Interest." Journal of Monetary Economics 13 (January 1984): 113-126.
- Sharpiro, Alan C. "What Does Purchasing Power Parity Mean?" Journal of International Money and Finance 2 (December 1983): 295-318.
- Viner, Jacob. Canada's Balance of International indebtedness 1900-1913. Cambridge: Harvard University Press, 1924.
- Yeager, Leland B. "A Rehabilitation of Purchasing Power Parity" Journal of Political Economy 66 (December 1958): 516-530.
- Zellner, A. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." Journal of the American Statistical Association (June 1962): 348-368.