This is to certify that the

dissertation entitled

ESSAYS ON THE MACROECONOMICS OF THE 1920s:
HYPERINFLATION, VOLATILITY AND MONEY DEMAND

presented by

Michael Raymond Redfearn

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Economics

R Baillie

Major professor

Date 7.27.1992

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.

DATE DUE	DATE DUE	DATE DUE
SEP 1 0 1997		

ESSAYS ON THE MACROECONOMICS OF THE 1920s: HYPERINFLATION, VOLATILITY AND MONEY DEMAND

By

Michael Raymond Redfearn

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Economics

1992

ABSTRACT

ESSAYS ON THE MACROECONOMICS OF THE 1920s: HYPERINFLATION, VOLATILITY AND MONEY DEMAND

By

Michael Raymond Redfearn

This dissertation consists of two essays:

1. "News and the Volatility of Exchange Rates" examines the time series properties of exchange rates for Belgium, Britain, France, Germany, Italy, Holland and Switzerland. Tests for cointegration between spot rates and forward rates are reported. No evidence is found for the theory that the spot exchange rates in this era were cointegrated. However, evidence is found for the stationarity of some forward premiums. Generalized Autoregressive Conditional Heteroskedastic models are estimated and are found to provide an adequate description of the first two conditional moments of the exchange rate data. The analysis then focuses on the volatility of exchange rates during the 1920s. The application of robust inferential techniques follows. The essay concludes by examining whether there exists any volatility spillovers between the various currencies. While the Italian and Swiss exchange rates show some departures from weak form efficiency, the 1920s market appears to be relatively efficient.

2. "Purchasing Power Parity and the Demand for Money in the 1920s" reexamines the existence of long-run Purchasing Power

Parity (PPP) in the 1920s for currency combinations between Belgium, Britain, France, Germany, Holland and the United States using both wholesale prices and different measures of retail prices. A maximum likelihood procedure due to Johansen (1988) is used. Some evidence consistent with purchasing power parity is found. However, some currency/price combinations yield more than one cointegrating relationship. The analysis then proceeds to use the existence of PPP to propose the forward premium as a proxy for inflationary expectations during high inflation periods. Demand for money equations are estimated and the results indicate that the forward premium is not a statistically significant variable for explaining the demand for money during high inflation episodes.

Dedicated to Amber, My Grandmother

ACKNOWLEDGEMENTS

I wish to thank my dissertation committee chairman, Professor Richard T. Baillie, for his comments, advice, and guidance over the period of this project. I also wish to thank my other committee members, Professor Rowena A. Pecchenino and Professor Robert H. Rasche, whose valuable comments, assistance and advice improved and helped complete this dissertation.

I would like to thank Margie Tieslau for her help and support during this undertaking; Dr. Lewis M. Abernathy, Chairman of the Department of Economics at the University of North Texas, for his support, advice and encouragement; Kari Foreback for providing excellent word processing assistance; and Roger Speas for providing computing assistance.

I also would like to thank my family: my parents, Patricia and Arnold Redfearn, and my brothers, David, Shawn and Scott for their support and encouragement of my efforts; and my grandparents for believing in me.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER II

CHAPTER III

LIST OF FIGURES

CHAPTER II

I. INTRODUCTION

CHAPTER I

INTRODUCTION

Widespread floating exchange rates in this century occurred during two periods; first from mid 1919 to 1928, and secondly from 1973 to the present day. A further period when some exchange rates floated occurred between 1931 and 1938 when most countries left the Gold Standard. Britain left the Gold Standard in 1931 and the United States abandoned gold in 1933. France, Belgium, Holland, Italy and Switzerland, the members of the Gold Bloc, remained on the Gold Standard until 1936 when the last of the remaining members, Holland and Switzerland, suspended the convertibility of their currencies and allowed them to freely depreciate in the market. Since there are approximately only two years when the whole system of exchange rates could potentially float freely, this period does not constitute a freely floating regime system. Since there are only two periods of floating exchange rates, analysis of the 1920s period is potentially useful for our understanding of exchange rates today.

The 1920s period is useful for examining questions of market efficiency, the desirability of different exchange rate regimes, the role of speculation in determining the behavior of exchange rates, the applicability of the purchasing power parity relationship, the formation of expectations, and the role of "news" in explaining the behavior of exchange rates.

The 1920s period is similar to the post 1973 period in several ways. Both followed periods in which nominal exchange rates had been explicitly fixed. This was accomplished by government decree during the First World War and by the Bretton Woods Agreement from 1944 - 1971.

The 1920s period is characterized by a wide variety of monetary and non-monetary events, including German war reparations between 1921 to mid 1924; the occurrence of the hyperinflation in Germany; the "bear squeezes" of M. Poincaré in March of 1924 and July of 1926; and the successful return of Great Britain to a gold type standard.

The 1920s period is an interim period of adjustment from war-enforced exchange rate parities to the pre-war gold or dollar parities. It was widely, although eventually erroneously, believed that domestic currencies would eventually return to their pre-war parity.

Unlike the recent float, the 1920s period had no intervention corresponding to anything as sophisticated as the European Monetary System where there are bands within which exchange rates are allowed to fluctuate. Generally exchange rates moved freely according to market conditions, although Belgium, Britain, France and Holland all intervened heavily in support of their respective currencies. However, there did not exist a concerted effort to force exchange rates to pre-war parity levels.

II. NEWS AND THE VOLATILITY OF EXCHANGE RATES

CHAPTER II

NEWS AND THE VOLATILITY OF EXCHANGE RATES

1. INTRODUCTION

As mentioned in Chapter I, the 1920s is one of the two periods of freely floating exchange rates in this century. Despite the relative abundance of data in the 1920s, relatively little research has examined the general time series properties of this floating regime. The focus of this essay is to examine the evolution of spot exchange rates; the volatility of the spot exchange rate; the effect of "news" on the volatility of exchange rates; and the possible existence of volatility spillovers between exchange rates.

Mussa (1979) notes that many exchange rates seem to possess tranquil and also highly volatile periods. Figures 1 through 6 plot the log of the weekly spot exchange rate from February 1922 through April 1925 for Belgium, Britain, France, Holland, Italy and Switzerland. Figures 7 through 12 plot the rate of return (the first difference of the log of the weekly spot rates) for the six countries over the same sample period. These plots confirm Mussa's observation concerning tranquil and volatile periods. This type of volatility clustering was first identified by Mandelbrot (1963) and Fama (1965) who noted this implied that price changes were not independent over time. This non-independence of price changes means that higher order moments of the distribution of prices are related. Thus, if both economic and noneconomic events are to be used to explain volatile periods, the model used must be able to account for clusters of volatility.

One such class of models is the Autoregressive Conditional Heteroskedastic (ARCH) model of Engle (1982) and the Generalized Autoregressive Conditional Heteroskedastic (GARCH) models of Bollerslev (1986) and Engle and Bollerslev (1986). The GARCH process specifically models time varying conditional variances, which are assumed to be influenced by lagged squared innovations and lagged conditional variances.

The present essay uses GARCH processes to model the volatility of the of the 1920s spot exchange rates.

Fama (1970, 1976, 1991) proposed three definitions of market efficiency which differ according to the information set available. In general, a financial market is efficient if prices fully and instantaneously reflect all available information. More specifically, a financial market is weak-form efficient if the information in past prices or returns is not useful in predicting future returns. A market is semi-strong-form efficient if all publicly available information is not useful in predicting future returns. Similarly, strong form efficiency requires both public and private information to be of no use in predicting future returns. If one exchange rate is influenced by another exchange rate's lagged innovation or volatility, then this is a violation of semi-strong efficiency.

There are institutional factors that could negatively influence the efficiency of the foreign exchange market. Advanced computer technology did not exist during the time period and long distance telephone service was unreliable. Also, Einzig (1962) pointed out that forward markets began to slowly reappear after 1919 and resulted in forward markets whose basic set up were not the same across geographical boundaries. These institutional factors could slow down the dissemination of information to market participants and hence lead to a violation of market efficiency.

Many authors have pointed out the importance of "news" on the behavior of financial markets; for example, Urich (1982), Roley (1983), O'Brien (1984), Hoffman and Schlagenhauf (1985), Hein (1985), Roley (1985), Bailey (1988), Cook and Hahn (1988), Baxter (1989), and Schirm, Sheehan, and Ferri (1989). These studies show, with varying degrees of success, that policy announcements can be very important in describing the behavior of the conditional mean of an asset's price. Thus, the identification of important events, both economic and noneconomic, even ex-post, gives the policy maker valuable insight into the behavior of past returns. It is, therefore, important to identify such events and to make allowances for them in the analysis.

This paper is organized as follows. The next section contains an analysis of the general time series properties of both the spot and forward exchange rates, with specific emphasis being given to the concepts of nonstationarity and cointegration. Section 3 builds the basic model. Section 4 investigates the effects of "news" on the volatility of spot exchange rates. Section 5 examines the existence of volatility spillovers, where the volatility of one exchange rate influences the volatility of another exchange rate. Section 6 contains a summary of the conclusions.

2. GENERAL TIME SERIES PROPERTIES

This section examines the general time series behavior of the log of the weekly spot rate, the 30-day forward rate, and the 90-day forward rate. Although subsequent analysis in this study only deals with the spot exchange rate, details concerning the forward rates are included for interest. Unit root tests are conducted to determine if the spot exchange rate follows a martingale. Tests for equilibrium relationships among various groups of exchange rates are also conducted.

The data used in this analysis are taken from Einzig (1937), and consist of exchange rates from seven countries: Belgium, Britain, France, Germany, Holland, Italy, and Switzerland. The rates quoted come from the Saturday of each week. When the market was closed on a Saturday, the last open day before Saturday was used. All the exchange rates were originally quoted with respect to the pound sterling. However, triangular arbitrage is used to express all the rates in terms of a numeraire U.S. dollar. Over the period of analysis, the U.S. dollar did not float freely and remained tied to gold until 1933. Since one of the goals of this study is to analyze the effect of news on the volatility of exchange rates, a stable numeraire is necessary to ensure that any movement in the exchange rate is due to movement in the particular currency under examination. A list of the data is provided in Appendix one.

The sample period for each of the series is from February 25, 1922 to April 4, 1925 which gives a total of 163 observations. However, the German sample period is truncated in September 1, 1923, since severe hyperinflation led to the suspension of the exchange of the Mark.

The existence of a unit root is an important issue to consider. Fama (1965) showed that successive changes in stock prices were uncorrelated, which is consistent with the martingale model. Hence, the current price of an asset reflects all available information and the expected one period rate of return to speculation is zero, which is in accord with weak form efficiency.

There have been many studies that examine the post Bretton Woods data for unit roots. Table 1 contains a summary of these results. Meese and Singleton (1982), Corbae and Ouliaris (1986) and Kim (1987) using weekly data, Baillie and Bollerslev (1989a) and Coleman (1990) using daily data and MacDonald and Taylor (1989), Baillie and Pecchenino (1991) and Shephton and Larson (1991) using monthly data show that a unit root could not be rejected. Therefore, there is evidence that daily and weekly exchange rates in the post Bretton Woods period contains a unit root.

To test the validity of the conclusion of Meese and Singleton, tests derived by Phillips and Perron (1988) and Kwiatkowski, Phillips, Schmidt, and Shin (1991) are applied to all the series. The Phillips-Perron tests are used instead of the Dickey-Fuller tests (Fuller (1976), Dickey and Fuller (1979), and Dickey and Fuller (1981)), since the Phillips-Perron tests are robust to many forms of time dependent heteroskedasticity. This point is important since many financial market time series exhibit time dependent heteroskedasticity.

The Phillips-Perron tests involve running the following three regressions using ordinary least squares:

$$y_t = \hat{\alpha}\, y_{t-1} + \hat{u}_t \tag{1}$$

$$y_t = \mu^* + \alpha^* y_{t-1} + u_t^* \tag{2}$$

$$y_t = \tilde{\mu} + \tilde{\beta}\,(t - T/2) + \tilde{\alpha} y_{t-1} + \tilde{u}_t \tag{3}$$

where T is the sample size and $\hat{u}_t$, u_t^* and $\tilde{u}_t$ are regression disturbances. In model (1) the null hypothesis of a unit root is tested against the stationary alternative, H_0: $\hat{\alpha} = 1$, versus H_a: $\hat{\alpha} < 1$ by the test statistic $Z(t_{\hat{\alpha}})$.

Model (2) provides a test for a unit root with or without drift, H_0: $\alpha^* = 1$ and H_0: $\mu^* = 0$, $\alpha^* = 1$ by the test statistics $Z(t_{\alpha^*})$ and $Z(\Phi_1)$, respectively.

Model (3), which allows for a deterministic trend, yields the following three null hypotheses: H_0: $\tilde{\alpha} = 1$, H_0: $\tilde{\beta} = 0$, $\tilde{\alpha} = 1$, and H_0: $\tilde{\mu} = 0$, $\tilde{\beta} = 0$, $\tilde{\alpha} = 1$. These are tested by the statistics $Z(t_{\tilde{\alpha}})$, $Z(\Phi_3)$, and $Z(\Phi_2)$, respectively. In all models, u_t is assumed to have limited memory and could be autocorrelated. The one percent and five percent critical values of all the above statistics are tabulated in Fuller (1976) and Dickey and Fuller (1981).

Table 2 shows the results of the Phillips-Perron tests for each of the countries. Apart from Germany, a unit root cannot be rejected for any exchange rate. The results for Germany indicate the possible existence of an explosive root. The joint hypothesis of a unit root with no drift is only rejected for the Italian 90-day forward rate. The inclusion of a time trend does not change the results. Overall, there is strong evidence for the presence of a unit root for six of the seven currencies.

The Kwiatkowski, Phillips, Schmidt, and Shin test statistics (hereafter KPSS) are partly motivated by the concern that standard unit root tests, which assume a null hypothesis of nonstationarity, fail to reject the null hypothesis too often. The KPSS test is based on a null hypothesis of stationarity.

The KPSS approach assumes a components representation that specifies the univariate time series as a sum of a deterministic trend, a random walk and a stationary disturbance. The test statistic is based on the Lagrange Multiplier score testing principle. The KPSS test is defined as:

$$\eta = T^{-2} \Sigma S_t^2 / s^2(k), \tag{4}$$

where

$$S_t = \sum_{i=1}^{t} e_i$$

is the partial sum of the residual e_i, when the series has been regressed on an intercept and possibly also a time trend; T is the sample size. $s^2(k)$ is a consistent nonparametric estimate of the disturbance variance and is computed using a Bartlett window adjustment based on the first k autocovariances as suggested by Newey and West (1987). The test statistic is denoted by $\hat{\eta}_\mu$ when the residuals are computed from an equation with only an intercept, and by $\hat{\eta}_\tau$ when a time trend is included in the regression. The critical values of $\hat{\eta}_\mu$ and $\hat{\eta}_\tau$ are 0.739 and 0.216 at the 0.01 level and 0.463 and 0.146 at the 0.05 level, respectively.

Table 3 contains the KPSS tests for the spot, 30-day forward, and 90-day forward rates when the series are regressed on a constant, and also when they are regressed on a constant with a time trend for the k=4 and k=8 cases. For the spot rates the hypothesis of trend stationarity can be rejected at the 5% level in all cases except Germany. The null hypothesis of level stationarity can be rejected at the 5% level for all countries except Britain and Holland. For the 30-day and 90-day forward rates the results are similar. The hypothesis of level stationarity can be rejected in all cases except for both the 30-day and 90-day forward rates for Britain and Holland. The null hypothesis of trend stationarity can be rejected for all cases except for the Italian series.

The results of the Phillips-Perron tests and KPSS tests are strongly supportive of a unit root in the series and suggest that all the series are nonstationary.[1] The Phillips-Perron tests indicate that German spot rate contains an explosive root, which is intuitively appealing, given the extreme currency depreciation that Germany experienced. The only major discrepancy between the two tests is the behavior of the British and Dutch series. However, given the fact that, in general, exchange rate series, both in the 1980s and 1920s, contain a unit root, analysis will proceed under the assumption that they contain a unit root.

We now consider the possible existence of long-run cointegrated relationships among the various spot exchange

---

[1] Phillips-Perron tests were performed on the first differences of all seven series. The null hypothesis of nonstationarity was rejected at the 1% level in every case. Thus, there do not appear to be two unit roots in any of the time series.

(

g

sp

sh

cer

run

coin

the

varia

prese

(1989,

equili

T

tests

also be

Belgium

rate series. Shepherd (1936) noted that the Belgian franc and the French franc should have similar co-movements due to the similarity of their economic conditions. Einzig (1937) pointed out that the Belgian and French francs tended to move together due to psychological factors. Aliber (1962) noted that the Belgian and French francs moved together because people believed that the French franc and the Belgian franc would eventually equal each other, as they did in the pre-war era. Finally, Einzig (1962) noted that the Belgian franc, French franc, and the Italian lira should have similar movements. He also stated that the movement of all western currencies tended to be synchronized. Figure 13 contains graphs of the log of the weekly Belgian, French, and Italian spot rates for February 1922 through April 1925 and clearly shows that there are common movements among the series at certain times. Formally, this suggests there may be a long-run relationship between the series which is consistent with cointegration. Tests for cointegration attempt to identify the existence of any long-run relationship between the variables in question. Appendix 2 contains a formal presentation of the Johansen (1988) and Johansen and Juselius (1989) framework for testing for the existence of a long-run equilibrium relationship.

Table 4 contains the results of the Johansen (1988) trace tests for cointegration between the six exchange rates and also between the subsets of Belgium, France, and Italy, and Belgium and France. The existence of a cointegrating relationship among the variables can be rejected in all cases. In addition, the residuals from a regression of the Belgium spot rate on a constant and the French spot rate are nonstationary, indicating a lack of long-run equilibrium relationship. Thus, despite the claims that certain spot rates during this period should move together, there is no evidence of a long-run cointegrating relationship.

There are strong theoretical reasons for believing that forward premia are stationary. This hypothesis could not be rejected on daily data in the 1980s by Baillie and Bollerslev (1989). Figure 14 contains graphs of the log of the weekly Swiss spot and 30-day forward rates for February 1922 through April 1925. As expected, these two rates have many similar co-movements. To test this hypothesis, trace tests were repeated for both the spot rate and the 30-day forward rate and the spot rate and the 90-day forward rate.

Table 5 provides tests for cointegration between the spot rates and the 30- and 90-day forward rates for Belgium, France, Italy, and Switzerland. Thus, for these pairs of exchange rates, there exists a long-run equilibrium relationship so that the forward premium is integrated of order zero. Table 5 also contains the likelihood ratio values for the hypothesis that the value of coefficients in the cointegrating relationship between the spot rate and the forward rate is: $s_t = f_t + \xi_t$. In no case can this form of the relationship be rejected. However, Table 5 indicates that a long-run equilibrium relationship does not exist for the British, Dutch, or German pairs.

Table 6 contains Phillips-Perron tests, KPSS tests, and the autocorrelation functions for the 30-day forward premium. The results indicate that the autocorrelation functions decay slowly for Britain, Holland and Switzerland; the existence of a unit root cannot be rejected for these countries using Phillips-Perron and KPSS tests. The results concerning Switzerland are in direct contrast to those using the trace test. Despite the result of the KPSS test the overall evidence indicates that the German forward premium is stationary.

Thus, the results from this section indicate that the series in this study are nonstationary with the German spot rate exhibiting explosive behavior. When the six spot rates are considered as a system, the cointegration tests indicate that there is no long-run equilibrium relationship. However, the forward premia for Belgium, France, Germany and Italy are stationary, where as those for Britain, Holland and Switzerland are nonstationary. These characteristics are used in the construction of the basic model in section 3.

3. THE BASIC MODEL

Section 2 suggests that the existence of a unit root can not be rejected by the data. This result implies that it is appropriate to specify the first difference of the log of the spot exchange rate as

$$100\ (\Delta \log s_t) = b + \epsilon_t \tag{5}$$

$$\epsilon_t | \Omega_{t-1} \sim N(0,\omega) \tag{6}$$

where s_t is the spot rate at time t, b is a constant, and ϵ_t is a random error term with a conditional normal distribution, with mean zero and variance ω. The random error is conditioned on Ω, the information set at time t-1.

Table 7 reports the results for six currencies together with the Ljung and Box (1978) test statistic Q(k) for kth order serial correlation in ϵ_t.[2] The null hypothesis for the Ljung-Box statistic is that changes in the spot rate are uncorrelated while under the alternative hypothesis they are generated by an AR(p) or MA(q) model. The only exchange rate which appears autocorrelated is Belgium. The statistics m_3 and m_4 are the sample measures of skewness and kurtosis, and are defined as the third and fourth moments around the mean. If the null hypothesis of a normal distribution is valid, then m_3 is asymptotically distributed as N(0,6/T) and m_4 as N(0,24/T). There is significant kurtosis present in all seven series which is in agreement with the results on exchange rates in the recent float; see Westerfield (1977), McFarland, Pettit and Sung (1982) and Hsieh (1989), Baillie and Bollerslev (1989b).

---

[2] Since the unit root tests indicate that unit root hypotheses for Germany may not be appropriate, the German results are only approximately correct. While the results appear in the tables, they will not be discussed formally.

Table 7 also contains the Ljung-Box test statistic for serial correlation in the squared residuals. The null hypothesis of no ARCH effects is rejected at the 5% level for all the series.

One class of models that is consistent with this type of behavior is the ARCH models of Engle (1982) and the GARCH models of Bollerslev (1986b) and Engle and Bollerslev (1986). GARCH models have been successfully applied to many types of financial time series. Diebold and Nerlove (1989), Baillie and Bollerslev (1989), Lastrapes (1989) and Baillie and Bollerslev (1991) apply these models to exchange rates in the present float. A regression model with GARCH innovations is given by:

$$y_t = x_t b + \epsilon_t \tag{7}$$

$$\epsilon | \Omega_{t-1} \sim N(0, \sigma^2_t) \tag{8}$$

$$\sigma^2_t = \omega_0 + \Sigma \alpha_i \epsilon^2_{t-i} + \Sigma \beta_i \sigma^2_{t-i} \tag{9}$$

where x_t is a vector of exogenous, or predetermined variables, ϵ_t is a random error, and A(L) and B(L) are polynomials in the lag operator. Following the results of previous studies, the GARCH(1,1) specification is imposed in the remainder of this study; i.e.

$$100\ (\Delta \log s_t) = b_0 + \epsilon_t \tag{10}$$

r

e

a

GA

the

con

rem

for

perm

exhi

being

Germa

parame

= 1 c

German

$$\epsilon_t | \Omega_{t-1} \sim N(0, \sigma^2_t) \tag{11}$$

$$\sigma^2_t = \omega_0 + \alpha\epsilon^2_{t-1} + \beta\sigma^2_{t-1} \tag{12}$$

Table 8 contains the results of estimating this model for all the currencies. The model was estimated using a Maximum Likelihood procedure which utilizes the Berndt, Hall, Hall, and Hausman (1974) algorithm. For all the exchange rates, the likelihood ratio test that both α and β are equal to zero is rejected. All coefficients are significant. There is no evidence of autocorrelation for any of the series.

The GARCH(1,1) process is stationary if $\alpha + \beta < 1$. When $\alpha + \beta = 1$ the process is integrated in variance or Integrated GARCH (IGARCH). In this situation an s step ahead forecast of the conditional variance is equal to the last value of the conditional variance, i.e. $E\sigma^2_{t+s} = \sigma^2_{t+1}$. Current information remains important for forecasts of the conditional variance for all horizons. Thus, a shock to the system today is permanent.

Table 8 reveals that both the British and Italian series exhibit a high degree of persistence with the sum of α and β being 0.867 and 0.943 respectively. For Belgium, France, Germany and Holland the sum of the estimates of the α and β parameters exceeds unity. A likelihood ratio test that $\alpha + \beta = 1$ could not be rejected for Belgium, Britain, France, Germany, Holland and Italy.

w

t

Th

of

exc

est

impl

valu

the

4.92

Italy

A feature of all the above models is the existence of excess kurtosis in the residuals. Baillie and Bollerslev (1989a) documented this same problem with exchange rate data in the 1980s and they estimated a GARCH model with t-distributed errors to daily, weekly, and fortnightly spot exchange rate data. Table 9 contains the results from estimation of the GARCH(1,1) model with a conditional Student t density. The model is

$$100\ \Delta\log s_t = b + \epsilon_t \tag{13}$$

$$\epsilon_t | \Omega_{t-1} \sim t(0, \sigma_t^2, \nu) \tag{14}$$

$$\sigma_t^2 = \omega + \alpha\epsilon_{t-1}^2 + \beta\sigma_{t-1}^2 \tag{15}$$

where ν is the degrees of freedom parameter, t is the Student-t distribution and all other variables are as defined above.

The substantive conclusions from Table 8 are still valid. The GARCH(1,1) model appears to be an adequate representation of the first two conditional moments of the data. However, excess kurtosis is still apparent for these models. The estimated value of ν, the degrees of freedom parameter, implies a conditional kurtosis equal to $3(\nu-2)(\nu-4)^{-1}$. This value can be compared to m_4 in Table 9. The value implied of the conditional kurtosis is 7.013, 11.915, 32.703, 4.425, 4.927, and 20.241 for Belgium, Britain, France, Holland, Italy, and Switzerland respectively, which is much larger than de

fur

dis

Foll

y_t co

Like

auxil

the sample kurtosis as measured by m_4 for all countries except Holland and Italy. Thus, using a Student-t density does not fully account for the leptokurtosis in the data.

The presence of excess kurtosis can lead to inappropriate inference and given the degree of excess kurtosis present in the exchange rate returns all the estimated models used in this study apply robust inference methods of Weiss (1986), Wooldridge (1990) and Bollerslev and Wooldridge (1991).

The robust procedure is based on a Quasi Maximum Likelihood Estimator (QMLE) which uses the standard Gaussian likelihood and is robust to departures from normality. The robust procedure can by described by letting

$$\mu_t(\theta) = E_{t-1}(y_t)$$

$$\sigma_t^2(\theta) = \mathrm{var}_{t-1}(y_t)$$

denote the conditional mean and the variance for y_t as a function of the px1 vector of unknown parameters θ. The disturbances are given by

$$\epsilon_t(\theta) \equiv y_t - \mu_t(\theta).$$

Following Bollerslev and Wooldridge (1991), if the model for y_t correctly parameterizes $\mu_t(\theta)$ and $\sigma_t^2(\theta)$, the Quasi Maximum Likelihood Estimator (QMLE) for θ, say $\hat{\theta}_T$, obtained under the auxiliary assumption of conditional normality, will under

Not
der
only
deri
cond
true

fairly general regularity conditions be $\sqrt{T}$ consistent for the true parameters, θ_0, and asymptotically normally distributed. Furthermore, a consistent estimate for the asymptotic covariance matrix for $\hat{\theta}_T$ is readily available, as

$$\sqrt{T}(\hat{A}_T^{-1}\hat{B}_T\hat{A}_T^{-1})^{-\frac{1}{2}}(\hat{\theta}_T - \theta_0) \xrightarrow{D} N(0,I) \tag{16}$$

where

$$\hat{A}_T = T^{-1} \cdot \sum_{t=1}^{T} [\nabla_\theta \mu_t(\hat{\theta}_T)' \nabla_\theta \mu_t(\hat{\theta}_T) \sigma_t^{-2}(\hat{\theta}_T)$$

$$+ .5 \nabla_\theta \sigma_t^2(\hat{\theta}_T)' \nabla_\theta \sigma_t^2(\theta_T)' \nabla \, \sigma_t^{-4}(\hat{\theta}_T)] \tag{17}$$

$$\hat{B}_T = T^{-1} \cdot \sum_{t=1}^{T} [\nabla_\theta \mu_t(\hat{\theta}_T)' \nabla_\theta \sigma_t^{-2}(\hat{\theta}_T) \;\; \epsilon(\hat{\theta}_T)$$

$$+ .5 \nabla_\theta \sigma_t^2(\hat{\theta}_T)' \sigma_t^{-4}(\hat{\theta}_T)(\epsilon_t^2(\hat{\theta}_T) - \sigma_t^2(\hat{\theta}_T))]$$

$$\nabla_\theta \mu_t(\hat{\theta}_T)' \;\; \nabla_\theta \sigma_t^{-2}(\hat{\theta}_T) \epsilon(\hat{\theta}_T) \; +$$

$$.5 \;\; \nabla_\theta \sigma_t^2(\hat{\theta}_T)' \sigma_t^{-4}(\hat{\theta}_T)(\epsilon_t^2(\hat{\theta}_T) - \sigma_t^2(\hat{\theta}_T))]' \tag{18}$$

Note, the expressions in (17) and (18) involve first derivatives of the conditional mean and variance functions only. This is particularly appealing when numerical derivatives are being used. Also, when the assumption of conditional normality is satisfied, the usual equalities hold true; i.e., $E(\hat{A}_T^{-1} \hat{B}_T \hat{A}_T^{-1}) = E(\hat{A}_T^{-1}) = E(\hat{B}_T^{-1})$.

c

r

ov

the

par

lik

star

do c

an a

momen

from

sectio

explai

rate c

While the preceding discussion assumed that the model correctly parameterizes both the conditional mean and the conditional variance functions, it is possible to show that the asymptotic covariance matrix in (16) remains valid under fairly general conditions, when the conditional mean is correctly specified, but the maintained assumption of conditional homoskedasticity, i.e. $\sigma^2_t(\theta) = \omega$ for all t, is violated. In that situation, the covariance matrix in (16) reduces to the well known covariance matrix adjustment in White (1982). Using this estimate of the asymptotic covariance matrix, Wald tests are conducted to test the relative importance of news and to test for volatility overspills.

Table 10 reports estimates of the GARCH(1,1) models using the robust standard error procedure. As expected, the parameter estimates and the value of the maximized log likelihoods are very close to the results in Table 8; the standard errors of the parameter estimates, on the other hand, do change.

The results indicate that the GARCH(1,1) model provides an adequate representation of the first two conditional moments of the exchange rate series. The GARCH(1,1) models from Table 10 are necessary for inference. In the next two sections this model will be used to examine whether news explains volatility and whether volatility of one exchange rate causes others to be volatile.

v

i

gr

th

Ta

th

Bri

com

move

are

patt

with

are:

4. THE IMPORTANCE OF NEWS AND THE VOLATILITY OF EXCHANGE RATES

This section considers the importance of news for explaining the volatility of the spot exchange rates. Figures 15 through 20 plot the rate of return for each of the six countries versus the conditional variance generated by the GARCH(1,1) process from Table 10 for the period February 1922 through April 1925. Each figure indicates that large fluctuations in the weekly rate of return are associated with spikes in the conditional variance; these fluctuations in the rate of return correspond to large innovations which, due to the GARCH(1,1) specification, increase the conditional variance. The focus of this section is to match the innovations with known events.

Table 11 contains the dates on which an innovation was greater than plus or minus two standard deviations away from the mean and also the corresponding sign of the innovation. Table 11 yields some interesting patterns. The only time when the Holland spot rate has a significant innovation is when Britain has one (note the converse is not true); there are six common movements. Belgium and France also share six common movements, but unlike the Britain-Holland relationship, there are three instances when the Belgium rate moves independently.

Further evaluation of Table 11 reveals eight distinct patterns or "episodes"; an episode is a time period associated with specific behavior of the innovations. The eight episodes are: the Italian Episode, October 28, 1922 - November 18,

s

m

re

wh

Mu

cor

wit

par

the

unce

The

1922; co-movement of the Belgian, French, and Italian spot rates on November 18, 1922; the Swiss Episode, June 30, 1923 - July 21, 1923; co-movement of the Belgian, Italian and Swiss spot rates on July 7, 1923; co-movement of the British and Dutch spot rates over the period November 10, 1923 - November 24, 1923; co-movement of the Belgian, British, Dutch, Italian, and Swiss spot rates on November 17, 1923; for France and Belgium, the Bear Squeeze, March 8, 1924 - March 22, 1924; and the co-movement of the British, Dutch, and Swiss spot rates on August 9, 1924.

The Italian episode covers the period from October 28, 1922 - November 18, 1922. This four week period consisted of a week of sharp depreciation followed by three weeks of appreciation. This episode is associated with the uncertainty surrounding the coming to power of Mussolini's Fascisti Party.

The government of Signor Facta did not have the votes to survive an election against the Fascisti. A consensus among ministers was reached on October 16 that the government should resign. This consensus quickly changed by October 18, 1922 when negotiations began between some of the old government and Mussolini. The rise to power was not due to armed confrontation, but from the support of the people. Associated with the rise of Mussolini is the fall of Signor Facta's party. This political event creates uncertainty not only from the change in the type of government, but also from the uncertainty associated with the policies of the new party. The new government moved quickly to stabilize public opinion

c

r

wh

"c

po

la

p.

Ger

mad

192

wou

bil

resp

repa

going

and instituted policies of new revenue collection, the elimination of many regional port authorities, and the simplification of tax laws.

The second episode is the co-movement of the Belgian, French, and Italian spot rates on November 18, 1922. In this incident, different factors influenced the Italian lira and the Belgian and French francs. The continued appreciation of the Lira was a continuation of the perceived positive influence of the new Italian government. The appreciation of the Belgian and French francs was a corrective effort from the over reaction of the previous week due to news on the reparations issue.

On June 28, 1919 the Treaty of Versailles was signed which required Germany to make reparations for all damage "done to the civilian population of the Allied and associate powers and their property by the aggression of Germany by land, by sea and from the air" (Moulton and Pasuolsky 1929 p.10). The treaty did not fix the total amount for which Germany was liable; the assessment of the total sum was to be made by May 1, 1921 by a reparation commission. On April 27, 1921 the commission determined the total German liability would be 132 billion gold marks with 68.64 billion, 13.20 billion and 10.56 billion going to France, Italy and Belgium respectively.

During the week of November 11, 1922 settlement of the reparation question (whether Belgium, France, and Italy were going to receive payments) did not seem probable. The German

T

o

f

a

in

op

Sw

eff

Nat

the

For

Swis

Itali

which

expla

government, under the severe financial restrictions place upon it by the reparations commission, was near collapse. The collapse of the government would mean that Belgium and France would be unable to receive reparation payments. However, at the end of this week, a report published by a panel of experts of the reparation committee indicated that Germany should be able to make its payments given the current state of German finances. This caused an appreciation of the French and Belgian currencies.

The third episode, the Swiss episode, was a reaction by the market to specific activities of the Swiss government. The first two weeks of this period were marked by depreciation of the franc. This depreciation was caused by capital outflow from Switzerland. This outflow was influenced by a threat of a capital levy, a lower Swiss capital rate than other industrialized countries, a scarcity of Swiss investment opportunities, a high rate of taxation and the conversion of Swiss francs to German marks by the German government. In an effort to stop the depreciation of its currency, the Swiss National Bank announced on July 14, 1923 that it would raise the official discount rate to 4% and the Lombard rate to 5%. For the next two weeks, there was a marked appreciation in the Swiss franc.

The next episode is the co-movement of the Belgian, Italian, and Swiss spot rates on July 7, 1923. The factors which accounted for the depreciation of the Swiss franc are explained above. The Belgian and Italian rates, along with a

w

S

g

pe

th

co

and

192

purc

norm

At th

the

Briti

demanc

affect

the French rate, were known as the reparation currencies. These currencies should be effected by adverse news about the reparations issue. In the week ending July 7, 1923 negotiations aimed at ending the Ruhr occupation had reached an impasse affecting the Belgian and Italian currencies.

The French currency did not suffer during this time for two reasons. First, the French government had been considering a British proposal for a solution to the crisis for approximately one month. Most French investors anticipated the attitude of the French government (i.e. France will not leave the Ruhr valley unless Germany agrees to pay). Second, there was good news for France during this week as the government passed the budgets for 1923 and 1924. While most people realized that these budgets were unattainable, given the protracted French budgetary process, this event was to be considered a success.

The fifth episode is the exact co-movement of the British and Dutch spot rates from November 10, 1923 - November 24, 1923. In Britain, there were heavier than usual seasonal purchases of cotton and grain from abroad. These larger than normal purchases meant a larger demand for foreign currency. At the same time, there was a capital outflow from Europe into the United States. Much of the funds flowed through the British currency market which affected the relative supply and demand for pounds. While this effect was not news, it did affect the British exchange rate.

t

t

de

ur

th

ab

Mor

Mar

tra

endi

For the Holland currency, the situation is unclear. It is possible that the Dutch authorities were reacting to what was happening to the British pound. As mentioned above, there are six common movements between the British and Dutch innovations. The pound was the international currency. Britain was the only European country that took explicit economic steps to ensure a return to the pre-war parity levels. The Dutch government may have been adjusting its exchange rate in order to retain a certain level of purchasing power between the two currencies. It is possible to test, using the Johansen (1988) framework, whether there exists a long-run relationship between these two spot rates. The trace statistic for $\leq$ 1 long-run relationship is 8.965 and for no long-run relationship is 2.146. Both these values are well below the critical values tabulated in Johansen (1988). Thus, there does not appear to be a long-run relationship.

The sixth episode is November 11, 1923, a day on which the Belgian, British, Dutch, Italian, and Swiss rates all depreciated. This is explained by the above mentioned uncertainty in Europe. Investors wanted a safe haven for their money. In addition, the U.S. interest rate climbed above the British rate, thus giving investors better returns. Money flowed out of Europe into the United States.

The seventh episode is the Bear Squeeze, March 8, 1924 - March 22, 1924. French Premier, Raymond Poincaré, intended to trap speculators operating on a bear market. On the week ending March 8, 1924, French and Belgian currencies were under

S

T

ir

qu

es

the

cha

of

vari

mark

even

excha

accou

speculative attack. Investors were liquidating their holdings of francs. In an effort to punish those who were selling short, M. Poincaré secretly negotiated loans from U.S. and British banks. Acting as French agents, the banks started buying large quantities of francs on March 11, 1924. The severe depreciation was reversed and for the next two weeks, both the French and Belgian francs appreciated sharply.

The final episode is August 9, 1924. On this day the British, Dutch, and Swiss spot rates all appreciated. For the Swiss rate, the realization by investors that the capital levy was an unlikely occurrence caused an inflow of funds. Also, there was an unexpected increase in tourism into Switzerland which increases the demand for the currency. Thus, money flowed back into the country.

For the British rate, the unexpected agreement by the inter-allied conference on the Ruhr occupation and reparation question led to a strengthening most currencies, but especially in Britain since Britain was the chief sponsor of the conference. If changes in the gilder are related to changes in the pound, Dutch authorities influenced the value of its currency to reflect changes in the value of the pound.

Hodgson (1972) and Baillie and Bailey (1985) use dummy variables in their analyses of the 1920s exchange rate markets. Hodgson used dummies to proxy the occurrence of events which might influence the evolution of the spot exchange rate. Baillie and Bailey use dummy variables to account for unpredictable periods of volatility. Lamoureux

t

w

hy

to

Oct

192

and

Rest

sign

these

condi

varia

associ

and Lastrapes (1990) have shown that large outliers in the innovation series implied that estimates of the conditional variance parameters could exhibit extreme persistence.

Table 12 contains the tests that the eight episodes are important for explaining volatile movements in the spot exchange rate. For each date tested, a dummy variable is included in the mean or the variance both individually and as a group. The GARCH(1,1) model is estimated using the robust estimation procedure and a Wald test is calculated for the significance of a dummy variable or of a group of dummies. Under the null hypothesis of zero restriction(s), the Wald test is distributed chi-squared with m degrees of freedom, where m is the number of restrictions.

For inferences concerning the conditional mean, the null hypothesis that the coefficient on the dummy variable is equal to zero is rejected except for the following instances: Italy, October 28, 1922; Switzerland, June 30, 1923 and July 14, 1923; Britain, November 10, 1923; Holland, November 10, 1923 and November 17, 1923; and Belgium and France, March 8, 1924. Restrictions on a group of dummy variables are all highly significant. Overall, excluding the above stated instances, these episodes are significant for explaining movement in the conditional mean of the spot rates in the GARCH(1,1) model.

The results for inferences about the conditional variances are less encouraging. All individual dummies associated with particular economic events are not

5

ra

an

du

Bri

thi

Dut

move

rate

sect

volat

heat

to be

marke

causes

anothe

significant, while groups of dummies are highly significant for the mean and variance.

Thus, the following observations can be made. First, country specific events are important for explaining volatility. Second, movement in the conditional variance is only significant when a long episode of volatile movement is observed.

5. VOLATILITY SPILLOVERS BETWEEN CURRENCIES

Section 4 demonstrated that there were times when certain rates did react to the same news. For instance, the French and Belgian rates during the Bear Squeeze, Belgium and Italy during the reparations controversy, and the co-movement of the British and Dutch rates. Moreover, a possible explanation of this co-movement is that the British rate started to move and Dutch officials intervened to adjust its currency. Thus, movements in the British rate led to movements in the Dutch rate. This idea of a volatility spillover is examined in this section.

Engle, Ito, and Lin (1990) developed two concepts of volatility spillovers: heat waves and meteor showers. In a heat wave, a reaction today in the New York market is likely to be followed tomorrow by a similar reaction in the New York market. A meteor shower is an occasion when an event that causes volatility in the New York market is transmitted to another market location.

s
a
s

c
l
p
a
ot
co
th

Engle, Ito and Lin (1990) using intra-daily foreign exchange rate data report evidence in favor of a spillover effect in volatility between different market locations. Hamao, Masulis and Ng (1990) examine volatility patterns in equity markets. Using opening and closing prices they find a spillover from the New York market to the Tokyo market, but not the converse. Baillie and Bollerslev (1991) using hourly data on four major floating exchange rates examine the relationship between return and volatility in different currency markets around the world. They find evidence that is consistent with the meteor shower hypothesis.

All the above studies use finely sampled data and data from several different markets. This study uses data from only one market. Thus, the ideas of heat waves and meteor showers are not directly applicable. However, the key idea of seeing how volatility spills over from one currency to another, either contemporaneously or with a lag, remains the same.

The innovation, conditional standard deviation and conditional variance series of the GARCH(1,1) model from Table 10 are used to examine volatility spillovers. The analysis proceeds in three steps. The conditional mean equation is augmented to include the estimated lagged innovations from other countries both individually and as a group. The conditional standard deviation of one currency is included in the conditional mean equation for another currency. Hence

I
s
s
c

de
Th
de
ar
sta
Nei
inf

cond
cond
as a
what

volatility on one exchange rate is allowed to influence mean returns on another.

The significance of any volatility term in explaining mean returns would imply a rejection of market efficiency. Thus, there are opportunities for profit exploitation.

Table 13 contains the results for estimation concerning the conditional mean equation. The null hypothesis is that the variable has a parameter value of zero. This hypothesis is tested by a Wald statistic with a chi-squared distribution with m degrees of freedom, m being the number of restrictions. No estimated lagged innovation, individually or as a group, is significant. Thus, despite some very large residuals in some series, these residuals do not affect the behavior of other conditional means.

There is some evidence that the conditional standard deviation is important for explaining the conditional mean. The Dutch conditional mean is influenced by the Swiss standard deviation, but not conversely. The Italian and Swiss means are affected by both the Belgian and French conditional standard deviations as well as all five standard deviations. Neither the Italian nor the Swiss standard deviation influences either the French or Belgian conditional means.

Table 14 contains the results of inferences in the conditional variance. Evidence is found that the Belgian conditional variance and all countries' conditional variances as a group influence volatility of the pound. This is perhaps what should be expected. The spot rates come from the London

T

w

B

e

s

ma

6.

exc

the

mod

het

spo

effe

sing

market. All transactions out of a certain exchange were made in pounds. Thus, increases in the variability of spot rates might cause investors to shift out of one currency into another. The French rate is also affected by the Belgian conditional variance, but not conversely. Both the Italian and Swiss variances are affected by the British and Dutch conditional variances. The Swiss rate is also influenced by all the conditional variances as a group.

Overall, the market seems to be relatively efficient. The Italian and Swiss rates seem to be the least efficient with Belgian and French conditional standard deviations and British and Dutch conditional variances being useful for explaining the volatility of these rates. Yet despite the seemingly primitive conditions of the 1920s foreign exchange market, the market was relatively efficient.

6. CONCLUSIONS

This study attempts to uncover the behavior of the exchange rates in the 1920s. Specific emphasis is given to the ideas of nonstationarity, cointegration, martingale models, generalized autoregressive conditional heteroskedasticity, the impact of news on the volatility of spot exchange rates, and the existence of volatility spillover effects.

The exchange rates examined in this study all possess a single unit root and are clearly nonstationary. A martingale

r
I
a

fo
he
es
ch
ex

GA
est
Sin
mea
pro
the

para

model was used since higher order moments of successive price changes were not independent.

There is no long-run relationship between the spot rate of Belgium, Britain, France, Holland, Italy, and Switzerland. Thus, during this time, these rates showed no tendency to move toward any long-run equilibrium. This is significant since most people believed that the spot rates would eventually return to their pre-war parity levels.

There is a cointegrating relationship between the spot rates and 30- and 90-day forward rates for Belgium, France, Italy and Switzerland and evidence that the forward premium are stationary.

The martingale models of section 3 were expanded to allow for the presence of time dependent conditional heteroskedasticity. A martingale GARCH(1,1) model was estimated for the seven exchange rates. The model characterizes the first two conditional moments of the spot exchange rates well (with the possible exception of Germany).

There was the presence of excess sample kurtosis in these GARCH(1,1) models. A conditional t distribution was estimated, but this did not account for the leptokurtosis. Since excess kurtosis can invalidate estimation concerning mean and variance parameters, a robust standard error procedure was employed. This martingale GARCH(1,1) model is the one used throughout the remainder of the paper.

Inferences concerning conditional mean and variance parameters were under taken to determine whether certain

t
b
j
r
r
ir
is

events cause increases in volatility. First, each spot rate is influenced by its own market fundamentals. Second, events, whether political or economic, affect the conditional mean more than the conditional variance. Third, the conditional variance is effected when a long string of events or one particular event lasts for a long time. Thus, a cumulative force is necessary for the conditional variance to be effected. Overall, news affects the behavior of the spot exchange rate.

The last section examines whether the volatility of one exchange rate is transmitted to another exchange rate. This question has direct implications for market efficiency. If the increase in volatility of one rate causes another rate to become more volatile, then knowing that the former rate has jumped is useful information about the behavior of the latter rate. Apart from some relationship between the Italian spot rate and the French, Belgian, British and Dutch rates and some influence on the Swiss rate, for the most part the conclusion is that the foreign exchange market is efficient.

TABLE 1

Summary of Unit Root Tests on Exchange Rates

Author	Countries Examined	Sample Period	Methodology	Results
Meese & Singleton (1982)	CN, GR, SW	1/7/76* - 7/8/81[w]	Dickey Fuller	Unit Roots
Corbae & Ouliaris (1986)	CN, GR, SW FR, UK, JP	1/2/76 - 1/2/85[w]	Phillips Perron	Unit Roots
Kim (1987)	CN, FR, GR IT, JP, SW UK	1973.1 - 1985.6[d,w,m]	REGF	No Unit Roots
Baillie & Bollerslev (1989)	FR, IT, GR JP, SW, UK	3/1/80 - 2/28/85[d]	Phillips Perron	Unit Roots
MacDonald & Taylor (1989)	AS, BL, DN FR, GR, IT HL, CN, JP UK	1973.1 - 1985.12[m]	Dickey Fuller	Unit Roots
Coleman (1990)	AU, DN, FN NZ, NW, SW, SP, SD	1/2/76 - 12/30/88[d]	Dickey Fuller	Unit Roots
	BL, CN, HL, FR, HK, IT, JP, SW, GR, UK	6/1/73 - 12/320/88[d]	Dickey Fuller	Unit Roots
Baillie & Pecchenino (1991)	UK	1973.3 - 1990.5[m]	Phillips Perron & KPSS	Unit Roots
Shephton & Larson (1991)	CN, GR, FR, JP, UK	1975.7 - 1988.12[m]	Dickey Fuller	Unit Roots

* The sample periods for Meese and Singleton (1982) are as follows: Canada, 1/7/76 - 6/24/81; West Germany, 1/7/76 - 7/2/81; and Switzerland, 1/7/76 - 7/8/81.

K
D
=
Z
S

K
R

TABLE 1 (cont'd)

Key: AS = Australia, AU = Austria, BL = Belgium, CN = Canada, DN = Denmark, FN = Finland, FR = France, GR = West Germany, HK = Hong Kong, HL = Holland, IT = Italy, JP = Japan, NZ = New Zealand, NW = Norway, SN = Singapore, SP = Spain, SD = Sweden, SW = Switzerland and UK = United Kingdom.

KPSS = Kwiatkowski, Phillips, Schmidt and Shin tests.

REGF is an F test where the log first difference of the spot rate is regressed on a constant and past first differences, and the coefficients on the lagged first differences are jointly tested for significance.

TABLE 2

Phillips-Perron Tests

	$Z(t_{\hat{\alpha}})$	$Z(t_{\alpha^*})$	$Z(\Phi_1)$	$Z(t_{\tilde{\alpha}})$	$Z(\Phi_2)$	$Z(\Phi_3)$
Belgium						
S_t	1.026	-1.906	2.547	-1.048	1.718	1.850
f_t^{30}	1.027	-1.910	2.556	-1.048	1.722	1.856
f_t^{90}	1.029	-1.921	2.577	-1.056	1.734	1.874
Britain						
S_t	0.814	-1.038	0.954	-1.136	0.866	0.890
f_t^{30}	0.820	-1.015	0.936	-1.126	0.876	0.899
f_t^{90}	0.828	-0.971	0.898	-1.108	0.894	0.923
France						
S_t	1.121	-1.642	2.212	-1.775	2.103	2.122
f_t^{30}	1.118	-1.654	2.227	-1.764	2.094	2.115
f_t^{90}	1.115	-1.674	2.253	-1.756	2.088	2.116
Germany						
S_t	2.845	1.964	4.495	0.248	4.947	2.703
f_t^{30}	2.378	1.678	2.833	-0.361	5.000	3.987
Holland						
S_t	-0.581	-1.438	1.231	-1.462	0.880	1.133
f_t^{30}	-0.578	-1.464	1.266	-1.491	0.903	1.171
f_t^{90}	-0.561	-1.511	1.326	-1.538	0.941	1.239

TABLE 2 (cont'd)

	$Z(\hat{t}_\alpha)$	$Z(t_\alpha{*})$	$Z(\Phi_1)$	$Z(\tilde{t}_\alpha)$	$Z(\Phi_2)$	$Z(\Phi_3)$
Italy						
S_t	0.740	-1.894	2.220	-2.558	2.558	3.325
f_t^{30}	0.727	-1.907	2.241	-2.576	2.590	3.387
f_t^{90}	0.028	-11.695	331.837	-31.374	276.380	416.149
Swit						
S_t	0.106	-1.485	1.121	-1.061	1.586	2.369
f_t^{30}	0.103	-1.504	1.149	-1.148	1.605	2.398
f_t^{90}	0.082	-1.679	1.686	-1.385	1.829	2.736

Key: The 5% critical values for $z(\hat{t}_\alpha)$, $z(t_\alpha{*})$ and $z(\tilde{t}_\alpha)$ are -1.95, -2.86, and -3.41 respectively. The 95% significance level for $z(\Phi_1)$, $z(\Phi_2)$ and $z(\Phi_3)$ are 4.59, 4.68 and 6.25 respectively.

TABLE 3

Kwiatkowski, Phillips, Schmidt and Shin Tests

Spot Rates

No Trend

	K=4	K=8
Belgium	2.429	1.409
Britain	0.387	0.227
France	2.674	1.561
Germany	1.612	0.972
Holland	0.359	0.210
Italy	1.751	1.075
Switzerland	0.779	0.451

Trend

	K=4	K=8
Belgium	0.688	0.417
Britain	0.381	0.222
France	0.524	0.333
Germany	0.181	0.134
Holland	0.384	0.224
Italy	0.098	0.409
Switzerland	0.706	0.222

TABLE 3 (cont'd)

30 day forward rates

No Trend

	K=4	K=8
Belgium	2.419	1.403
Britain	0.399	0.235
France	2.667	1.556
Germany	1.651	0.987
Holland	0.363	0.213
Italy	1.729	1.065
Switzerland	0.752	0.436

Trend

	K=4	K=8
Belgium	0.690	0.418
Britain	0.383	0.223
France	0.530	0.335
Germany	0.167	0.129
Holland	0.385	0.225
Italy	0.100	0.065
Switzerland	0.706	0.410

TABLE 3 (cont'd)

90 day forward rates

No Trend

	K=4	K=8
Belgium	2.406	1.395
Britain	0.425	0.250
France	2.648	1.544
Holland	0.374	0.220
Italy	0.872	0.666
Switzerland	0.728	0.426

90-day forward rates

Trend

	K=4	K=8
Belgium	0.693	0.419
Britain	0.387	0.226
France	0.541	0.340
Holland	0.392	0.229
Italy	0.059	0.050
Switzerland	0.698	0.409

Key: The no trend test statistic corresponds to the partial sum of the residuals from an OLS regression on a constant. The trend case includes a time trend and a constant. K equals the number of lags in the residual series.

Table 4

Trace Tests For Cointegration

Spot Exchange Rates

	r=0	r≤1	r≤2	r≤3	r≤4	r≤5
all spot rates	66.520	43.517	24.431	12.670	4.780	0.072
BL/FR/IT spot	16.338	5.871	2.329			
BL/FR spot	6.517	2.670				

Key: BL = Belgium, FR = France and IT = Italy. The number of lags in the vector autoregression, K, to ensure white noise residuals was set equal to 3. All spot rates refers to the test of Belgium, Britain, France, Holland, Italy and Switzerland.

Table 5

Trace Tests for Cointegration

Spot and Forward Rate Combinations

	$r = 0$	$r \leq 1$
BL-30	28.161	4.626
BL-90	21.589	4.154
BR-30	3.716	0.842
BR-90	3.928	0.570
FR-30	32.128	3.972
FR-90	28.460	4.011
GR-30	10.535	0.902
HL-30	15.764	4.223
HL-90	14.698	4.442
IT-30	31.712	5.509
IT-90	46.648	5.823
SW-30	22.311	5.830
SW-90	28.964	2.713

TABLE 5 (cont'd)

Likelihood Ratio Tests

$$s_t = f_t + \xi_t$$

	Spot - 30 day	Spot - 90 day
BL	0.103	0.080
FR	0.150	0.127
IT	0.167	0.174
SW	0.057	0.146

Key : BL = Belgium, BR = Britain, FR = France, GR = Germany, HL = Holland, IT = Italy and SW = Switzerland. To ensure the residuals are white noise, K, the number of lags in the vector autoregression was set at 3 for BL-90, FR30, FR90, BL/FR/IT, and all spot; K was set equal to 4 for BL30, BR30, BR90, HL30, HL90, IT30, IT90, SW30, and SW90. K was set at 5 for Germany.

TABLE 6

Weekly 30-day Forward Premium

Phillips-Perron Tests

	$Z(t_{\hat{\alpha}})$	$Z(t_{\alpha}*)$	$Z(\Phi_1)$	$Z(t_{\tilde{\alpha}})$	$Z(\Phi_2)$	$Z(\Phi_3)$
Belgium	-8.016	-8.564	181.162	-10.074	160.120	240.315
Britain	-1.308	-1.559	1.234	-2.051	1.664	2.493
France	-2.522	-2.856	9.046	-3.244	8.244	12.20
Germany	-3.959	-4.878	59.181	-7.020	70.894	109.737
Holland	-2.234	-2.242	2.645	-2.218	1.766	2.641
Italy	-10.439	-12.479	350.875	-12.921	251.476	377.457
Swit	-1.794	-1.792	1.649	-2.179	1.646	2.646

KPSS Tests

	Trend		No Trend	
	K=4	K=8	K=8	K=4
Belgium	0.155	0.122	1.074	0.764
Britain	0.474	0.280	1.170	0.679
France	0.120	0.094	0.889	0.643
Germany	0.143	0.125	0.711	0.544
Holland	0.328	0.206	0.439	0.273
Italy	0.105	0.088	0.432	0.349
Swit	0.247	0.154	1.558	0.920

Table 6 (cont'd)

Autocorrelation Functions

Lag	Belgium	Britain	France	Germany	Holland	Italy	Swit
1	0.267	0.965	0.733	0.310	0.910	0.098	0.951
2	0.221	0.938	0.523	0.376	0.823	0.190	0.911
3	0.217	0.915	0.378	0.237	0.760	0.122	0.875
4	0.200	0.889	0.296	0.291	0.709	0.079	0.836
5	0.191	0.852	0.210	0.104	0.631	0.075	0.749
6	0.169	0.814	0.208	0.077	0.568	0.067	0.794
7	0.186	0.776	0.229	0.037	0.517	0.070	0.709
8	0.171	0.744	0.339	0.032	0.466	0.056	0.678
9	0.175	0.704	0.296	0.034	0.410	0.087	0.632
10	0.112	0.670	0.216	0.036	0.353	0.043	0.587
11	0.101	0.633	0.180	0.029	0.317	0.035	0.546
12	-0.012	0.594	0.151	0.029	0.259	0.040	0.519

Key: The 5% critical values for $Z(t_{\hat{\alpha}})$ $Z(t_{\alpha}*)$ and $Z(t_{\tilde{\alpha}})$ are -1.95, -2.86 and -3.41, respectively. The 95% significance levels for $Z(\Phi_1)$, $Z(\Phi_2)$, and $Z(\Phi_3)$ are 4.59, 4.68 and 6.25, respectively. For the KPSS tests, K is the number of lags in the residual series; the 5% critical values are 0.146 when a trend term is included in the regression and 0.463 when only a constant is included in the regression.

TABLE 7

Estimation of the Model

$$100\ \Delta \log s_t = b + \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N(0, \omega)$$

	BL	BR	FR	GR	HL	IT	SW
b	0.324	-0.052	0.349	13.498	-0.026	0.129	0.009
	(0.292)	(0.050)	(0.340)	(3.167)	(0.049)	(0.145)	(0.051)
ω	12.008	0.383	13.883	627.168	0.302	3.353	0.441
	(0.752)	(0.027)	(0.595)	(66.878)	(0.015)	(0.292)	(0.030)
Log L	-431.23	-151.807	-443.732	-366.631	-133.114	-328.140	-163.23
Q(10)	27.951	8.887	15.261	13.658	5.753	10.191	16.001
$Q^2(10)$	40.043	18.090	18.717	10.130	61.105	75.541	28.073
m_3	-0.974	-0.432	-2.163	1.804	-0.041	0.162	0.215
m_4	8.229	6.041	18.774	6.605	10.483	4.275	6.572

Key: All countries were estimated for T = 162 weekly observations from February 25, 1922 through March 28, 1925. Standard errors are in parentheses below the corresponding parameter estimates; m_3 and m_4 are respectively the sample skewness and kurtosis coefficients of the standardized residuals. Under the assumption of normality $m_3 \sim N(0,6/T)$ and $m_4 \sim N(3, 24/T)$ asymptotically. Q(10) and $Q^2(10)$ are the Ljung Box statistics based on the first 10 lags of autocorrelation of the standardized residuals, and the squared residuals respectively.

TABLE 8

Estimation of the Model

$$100\ \Delta \log s_t = b + \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N(0, \sigma^2_t)$$

$$\sigma^2_t = \omega + \alpha^2_{t-1} + \beta\sigma^2_{t-1}$$

	BL	BR	FR	GR	HL	IT	SW
b	0.016 (0.195)	-0.060 (0.039)	0.211 (0.237)	4.839 (2.476)	0.004 (0.025)	0.145 (0.148)	0.029 (0.051)
ω	0.258 (0.193)	0.075 (0.034)	0.761 (0.322)	31.584 (36.035)	0.014 (0.006)	0.200 (0.084)	0.141 (0.040)
α	0.521 (0.124)	0.387 (0.142)	0.429 (0.092)	0.606 (0.236)	0.490 (0.114)	0.214 (0.083)	0.410 (0.106)
β	0.591 (0.062)	0.480 (0.123)	0.586 (0.066)	0.565 (0.144)	0.533 (0.082)	0.729 (0.070)	0.287 (0.129)
Log L	-398.98	-141.482	-404.87	-358.54	-90.14	-310.92	-146.48
Q(10)	13.12	15.57	7.34	10.90	16.18	8.21	18.93
$Q^2(10)$	7.72	10.70	13.40	7.44	7.01	14.29	2.79
m_3	0.03	-0.76	0.18	0.46	0.03	0.35	0.06
m_4	4.12	5.90	4.34	3.77	3.71	3.85	4.66
LR	64.50	20.62	77.72	16.18	41.97	34.44	33.50

Key: All countries were estimated for T = 162 weekly observations from February 25, 1922 through March 28, 1925. Standard errors are in parentheses below the corresponding parameter estimates; m_3 and m_4 are respectively the sample skewness and kurtosis coefficients of the standardized residuals. Under the assumption of normality, $m_3 \sim N(0,6/T)$ and $m_4 \sim N(3, 24/T)$ asymptotically. Q(10) and $Q^2(10)$ are the Ljung Box statistics based on the first 10 lags of autocorrelation of the standardized residuals, and the squared residuals respectively. The likelihood ratio test tests the null hypothesis that α and $\beta = 0$.

L

au

res

TABLE 9

Estimation of the Model

$$100\ \Delta \log s_t = b + \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim t(0, \sigma^2_t, \nu)$$

$$\sigma^2_t = \omega + \alpha\epsilon^2_{t-1} + \beta\sigma^2_{t-1}$$

	BL	BR	FR	GR	HL	IT	SW
b	0.103 (0.173)	-0.036 (0.089)	0.260 (0.194)	7.921 (2.439)	0.012 (0.025)	0.159 (0.120)	0.027 (0.041)
ω	0.389 (0.338)	0.134 (0.078)	0.787 (0.531)	66.266 (99.940)	0.011 (0.006)	0.283 (0.175)	0.094 (0.055)
α	0.535 (0.196)	0.432 (0.236)	0.421 (0.189)	0.379 (0.296)	0.463 (0.150)	0.322 (0.160)	0.372 (0.183)
β	0.579 (0.053)	0.285 (0.236)	0.621 (0.105)	0.682 (0.234)	0.577 (0.101)	0.620 (0.111)	0.468 (0.192)
$1/\nu$	0.182 (0.053)	0.214 (0.032)	0.238 (0.039)	0.235 (0.049)	0.130 (0.065)	0.142 (0.047)	0.230 (0.053)
Log L	-395.45	-131.11	-399.43	-355.57	-88.46	-308.64	-140.62
Q(10)	13.249	12.265	7.067	10.520	17.476	8.651	18.594
$Q^2(10)$	7.568	10.107	15.117	7.424	8.287	17.234	3.950
m_3	0.091	-0.893	0.169	0.617	0.069	0.414	0.175
m_4	4.118	6.773	4.442	4.294	3.797	4.058	4.838

Key: All countries were estimated for T = 162 weekly observations from February 25, 1922 through March 28, 1925. Standard errors are in parentheses below the corresponding parameter estimates; m_3 and m_4 are respectively the sample skewness and kurtosis coefficients of the standardized residuals. Under the assumption of normality, $m_3 \sim N(0,6/T)$ and $m_4 \sim N(3, 24/T)$ asymptotically. Q(10) and $Q^2(10)$ are the Ljung Box statistics based on the first 10 lags of autocorrelation of the standardized residuals, and the squared residuals respectively.

TABLE 10

Estimation and Robust Inference on the Model

$$100\ \Delta \log s_t = b + \epsilon_t$$

$$\epsilon_t | \Omega_{t-1} \sim N(0, \sigma^2_t)$$

$$\sigma^2_t = \omega + \alpha \epsilon^2_{t-1} + \beta \sigma^2_{t-1}$$

	BL	BR	FR	GR	HL	IT	SW
b	0.013 (0.129)	-0.060 (0.049)	0.203 (0.143)	5.247 (1.271)	0.004 (0.022)	0.152 (0.083)	0.031 (0.036)
ω	0.268 (0.184)	0.076 (0.042)	0.763 (0.462)	34.701 (24.860)	0.006 (0.009)	0.201 (0.193)	0.140 (0.070)
α	0.517 (0.168)	0.394 (0.137)	0.429 (0.191)	0.581 (0.232)	0.483 (0.184)	0.215 (0.087)	0.410 (0.220)
β	0.591 (0.094)	0.473 (0.181)	0.586 (0.117)	0.571 (0.095)	0.533 (0.113)	0.728 (0.124)	0.290 (0.250)
Log L	-398.99	-146.492	-404.87	-358.54	-90.14	-310.92	-146.48
Q(10)	12.84	15.22	7.12	10.54	16.04	7.97	18.53
$Q^2(10)$	6.98	10.52	13.04	7.21	6.73	13.82	2.72
m_3	0.03	-0.77	0.18	0.48	0.03	0.36	0.07
m_4	4.12	5.92	4.33	3.80	3.71	3.86	4.66

Key: All countries were estimated for T = 162 weekly observations from February 25, 1922 through March 28, 1925. Standard errors are in parentheses below the corresponding parameter estimates; m_3 and m_4 are respectively the sample skewness and kurtosis coefficients of the standardized residuals. Under the assumption of normality $m_3 \sim N(0,6/T)$ and $m_4 \sim N(3, 24/T)$ asymptotically. Q(10) and $Q^2(10)$ are the Ljung Box statistics based on the first 10 lags of autocorrelation of the standardized residuals, and the squared residuals respectively.

Table 11

Volatility Patterns From Robust GARCH Estimation

6/24/22	IT:+	8/11/23	GR,SW:+,-
7/8/22	IT:+	9/1/23	GR:+
8/26/22	IT:+	11/10/23	BR,HL:+
10/28/22	IT:+	11/17/23	BL,BR,HL,IT,SW:+
11/4/22	IT,SW:-	11/24/23	BR,HL:-
11/11/22	IT:-	2/2/24	BR,HL:+
11/18/22	BL,FR,IT:-	3/8/24	BL,FR:+
12/16/22	BR:-	3/15/24	BL,FR:-
1/20/23	GR:+	3/22/24	BL,FR:-
2/17/23	GR:-	4/5/24	BL:-
6/30/23	GR,SW:+	5/10/24	BL,FR:+
7/7/23	BL,IT,SW:+	7/12/24	SW:-
7/14/23	SW:-	8/9/24	BL,BR,HL,SW:-
7/21/23	SW:-	8/23/24	BR:+
7/28/23	GR:+	9/6/24	BR,HL:+

Key: BL = Belgium, BR = Britain, FR = France, GR = Germany, HL = Holland, IT = Italy and SW = Switzerland. Each date is associated with a residual value that is greater than plus or minus two standard deviations away from the mean. The plus (+) sign indicates depreciation of the currency whereas the minus (-) sign indicates appreciation.

Table 12

Wald Tests From Robust Estimation with Dummy Variables

	Mean	Variance
Italian Episode		
10/28/22	0.877	8.266
11/4/22	4271.380	0.623
11/11/22	4230.935	0.001
11/18/22	3204.054	0.552
10/28/22- 11/18/22	5896.790	7523.930
11/18/22		
Belgium	6957.672	0.285
France	359.131	0.463
Italy	3204.054	0.552
Swiss Episode		
6/30/23	0.010	3.147
7/7/23	14.955	6.001
7/14/23	0.480	0.396
7/21/23	15.485	0.003
6/30/23 - 7/21/23	298263.000	764.474

Table 12 (cont'd)

7/7/23		
Belgium	730.781	1.277
Italy	2444.000	0.655
Switzerland	14.928	0.024
11/10/23 - 11/24/23		
Britain		
11/10/23	0.071	2.26
11/17/23	137.825	0.647
11/24/23	1122.250	0.977
11/10/23 - 11/24/23	1372.57	170.985
Holland		
11/10/23	0.096	3.196
11/17/23	0.528	1.441
11/24/23	6113.549	0.023
11/10/23 - 11/24/23	14998.300	1586.65
11/17/23		
Belgium	94.974	0.841
Britain	137.825	0.647
Holland	0.528	1.441
Italy	2017.068	0.655
Switzerland	8.876	3.681

Table 12 (cont'd)

3/8/24 - 3/22/24		
Belgium		
3/8/24	0.029	2.067
3/15/24	1719.03	0.665
3/22/24	5127.127	3.415
3/8/24 - 3/22/24	76.785	816.883
France		
3/8/24	0.019	1.056
3/15/24	1145670.501	0.426
3/22/24	8844.471	3.337
3/8/24 - 3/22/24	12409.200	17.337
8/9/24		
Britain	25.708	2.985
Holland	7.731	3.651
Switzerland	121.893	1.368

Key: The mean and variance columns represent the Wald test value when a dummy variable or a series of dummy variables is placed in the mean or variance respectively. The values have a $\chi^2_{(m)}$ distribution where m is the number of dummy variables in the conditional mean or conditional variance equation.

$\hat{\epsilon}$

$\hat{\epsilon}$

$\hat{\epsilon}$ (

$\hat{\epsilon}$ (

$\hat{\epsilon}$ (S

$$\sum_{j=1}^{5} \epsilon$$

Key:

χ_1^2 d

the

row o

other

equat

incluc

Table 13

Robust WALD Tests for Causality in the Mean

$$100\Delta s_{it}=b_i+\epsilon_{it}+\gamma_j\hat{\epsilon}_{jt-1}$$

$$\epsilon_t|\Omega_{t-1}\sim N(0,\sigma^2_{it})$$

$$\sigma^2_{it}=\omega_i+\alpha_i\epsilon^2_{it-1}+\beta_i\sigma^2_{it-1}$$

Lagged Residual Values

	BL	BR	FR	HL	IT	SW
$\hat{\epsilon}(BL)_{t-1}$	1.000	0.074	0.314	0.141	1.586	0.132
$\hat{\epsilon}(BR)_{t-1}$	0.050	0.000	0.880	0.5000	0.00001	0.545
$\hat{\epsilon}(FR)_{t-1}$	0.169	0.250	0.088	0.020	0.911	0.141
$\hat{\epsilon}(HL)_{t-1}$	0.427	0.844	0.017	0.027	0.013	0.0001
$\hat{\epsilon}(IT)_{t-1}$	0.391	0.790	0.496	0.128	1.235	0.479
$\hat{\epsilon}(SW)_{t-1}$	0.238	0.629	0.045	1.111	3.104	5.219
$\sum_{j=1}^{5}\hat{\epsilon}_{jt-1}$	8.655	3.224	9.341	3.768	3.945	1.805

Key: All the elements in the first six rows have an asymptotic χ_1^2 distribution under the null hypothesis and the elements of the last row are asymptotically χ_5^2 distributed. The final row of the table denotes the Wald test statistic when all five other lagged conditional residuals are included in the equation for mean returns. Own lagged residuals are not included.

$\hat{\sigma}$

$\hat{\sigma}$

$\hat{\sigma}$

$\hat{\sigma}$ (

$\sum_{j=1}^{5}$

Key

χ_1^2

the

row

othe

the

stanc

Table 13 (cont'd)

$$100\Delta s_{it}=b_i+\epsilon_{it}+\gamma_j\hat{\sigma}_{jt}$$

Conditional Standard Deviation

	BL	BR	FR	HL	IT	SW
$\hat{\sigma}(BL)_t$	0.898	1.000	1.128	2.116	14.916	9.434
$\hat{\sigma}(BR)_t$	0.560	1.054	0.055	0.0001	1.359	0.183
$\hat{\sigma}(FR)_t$	0.336	2.678	2.384	0.826	13.351	5.556
$\hat{\sigma}(HL)_t$	0.699	2.589	0.007	0.184	0.498	1.0321
$\hat{\sigma}(IT)_t$	0.474	1.214	0.084	2.028	9.620	1.588
$\hat{\sigma}(SW)_t$	4.386	0.286	0.046	4.054	3.340	0.885
$\sum_{j=1}^{5}\hat{\sigma}_{jt}$	7.487	10.162	4.302	6.517	31.935	15.216

Key: All the elements in the first six rows have an asymptotic χ_1^2 distribution under the null hypothesis and the elements of the last row are asymptotically χ_5^2 distributed. The final row of the table denotes the Wald test statistic when all five other lagged conditional standard deviations are included in the equation for mean returns. Own lagged conditional standard deviations are not included.

$\hat{\sigma}$

$\hat{\sigma}$

$\hat{\sigma}^2$

$\hat{\sigma}^2_j$

$\sum_{j=1}^{5}$

Key:
χ_1^2
the
row
other
the
inclu

Table 14

Robust Wald Tests for Causality in Variance

$$100\Delta s_{it}=b_i+\epsilon_{it}$$

$$\epsilon_{it}|\Omega_{t-1}\sim N(0,\sigma^2_{it})$$

$$\sigma^2_{it}=\omega_i+\alpha_i\epsilon^2_{it-1}+\beta_i\sigma^2_{it-1}+\delta_j\hat{\sigma}^2_{jt}$$

	BL	BR	FR	HL	IT	SW
$\hat{\sigma}^2_j$(BL)	----	20.250	4.514	0.563	1.000	0.111
$\hat{\sigma}^2_j$(BR)	1.250	----	0.142	1.591	8.869	29.566
$\hat{\sigma}^2_j$(FR)	0.0003	1.000	----	0.444	4.000	0.442
$\hat{\sigma}^2_j$(HL)	0.857	1.000	0.028	----	9.990	5.760
$\hat{\sigma}^2_j$(IT)	1.700	0.640	1.846	0.444	----	0.0001
$\hat{\sigma}^2_j$(SW)	3.642	0.016	0.307	0.009	1.313	----
$\sum_{j=1}^{5}\hat{\sigma}^2_{jt}$	4.922	26.542	8.291	3.476	5.838	26.865

Key: All the elements in the first six rows have an asymptotic χ_1^2 distribution under the null hypothesis and the elements of the last row are asymptotically χ_5^2 distributed. The final row of the table denotes the Wald test statistic when all five other conditional variances are included in the equation for the conditional variance. Own conditional variances are not included.

34

32

3

28

26

24

-144

-146

-148

-15

-152

-154

-156

-158

Figure 1
Log of the Weekly Belgian Spot Rate
February 1922 - April 1925

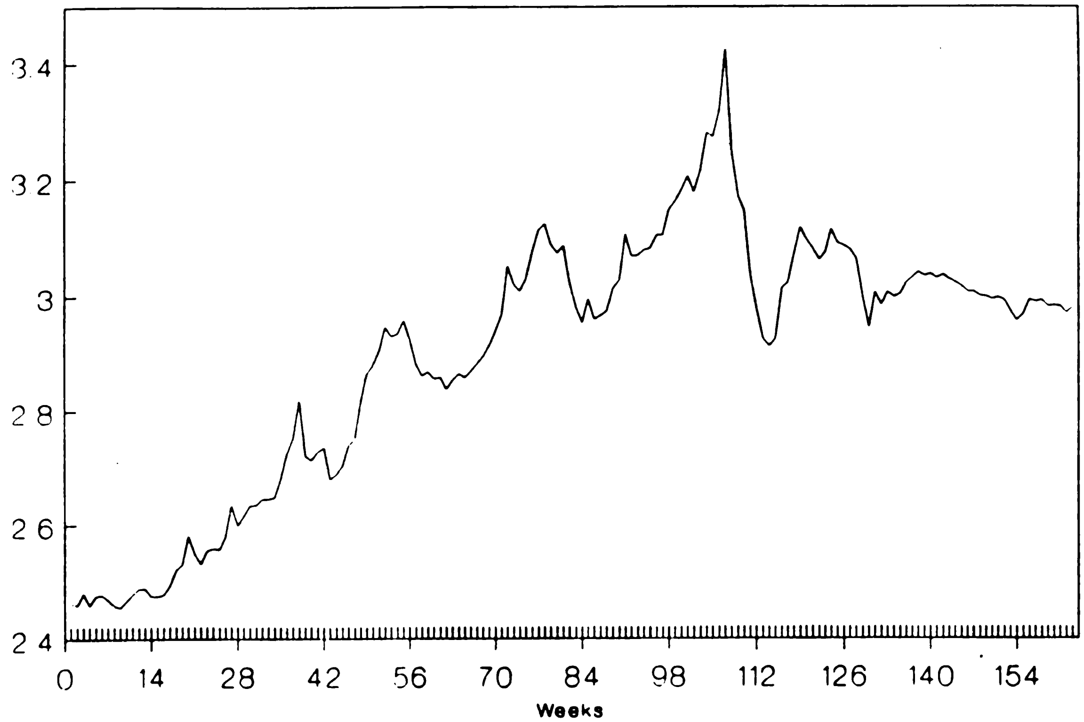
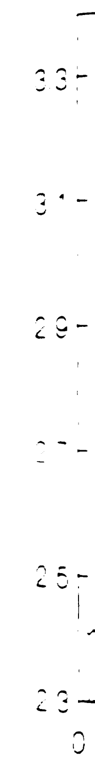
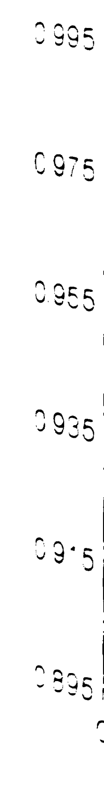


Figure 2
Log of the Weekly British Spot Rate
February 1922 - April 1925



33
31
29
25
23
0



0.995
0.975
0.955
0.935
0.895

Figure 3
Log of the Weekly French Spot Rate
February 1922 - April 1925

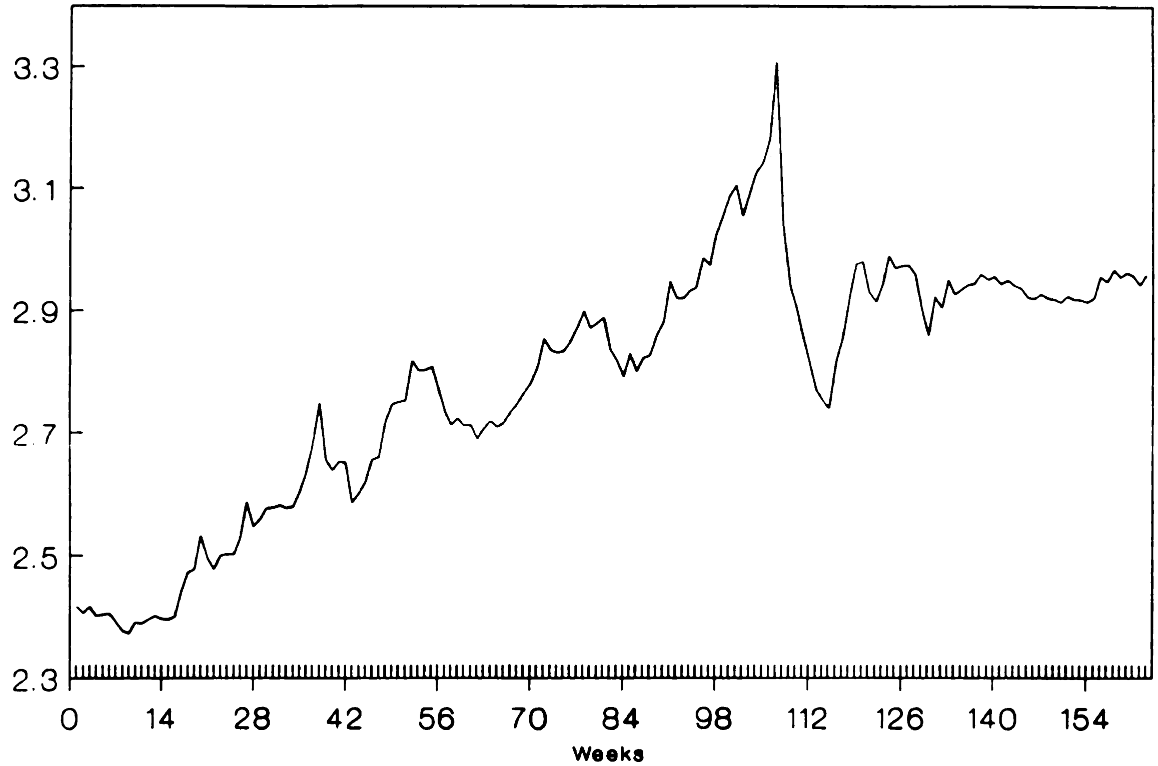
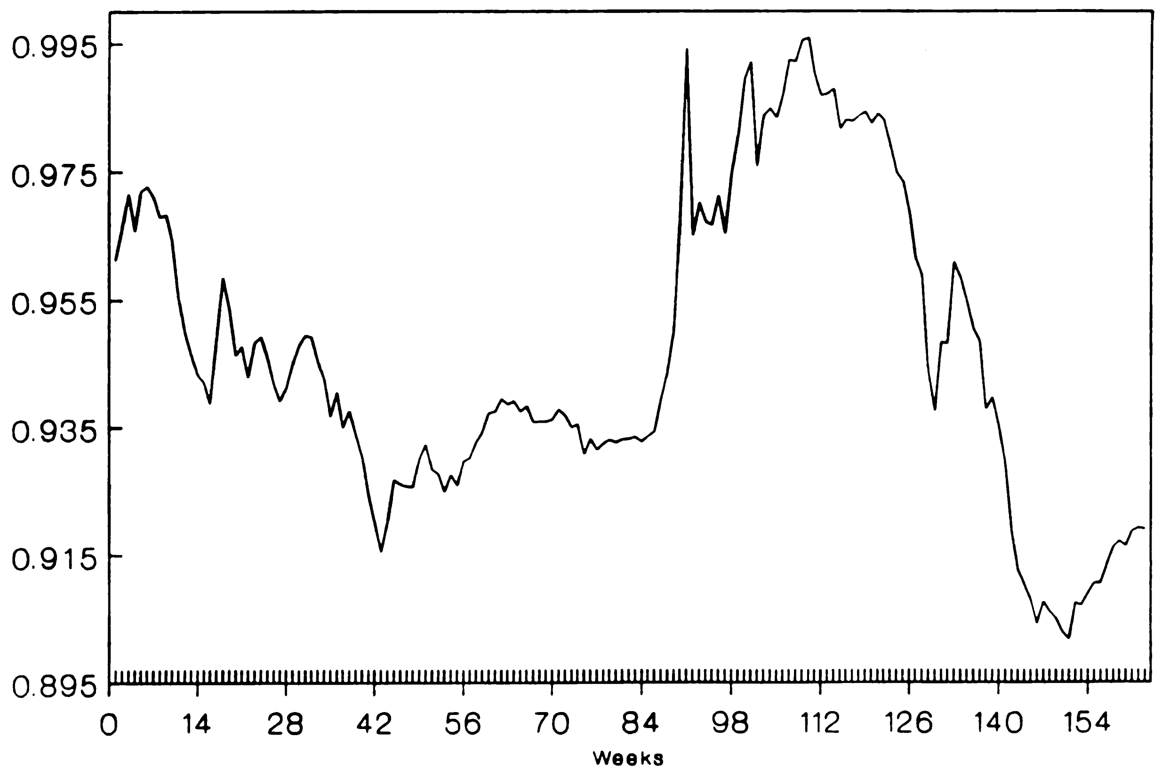


Figure 4
Log of the Weekly Dutch Spot Rate
February 1922 - April 1925




325
315
305
295
285
166
162

Figure 5
Log of the Weekly Italian Spot Rate
February 1922 - April 1925

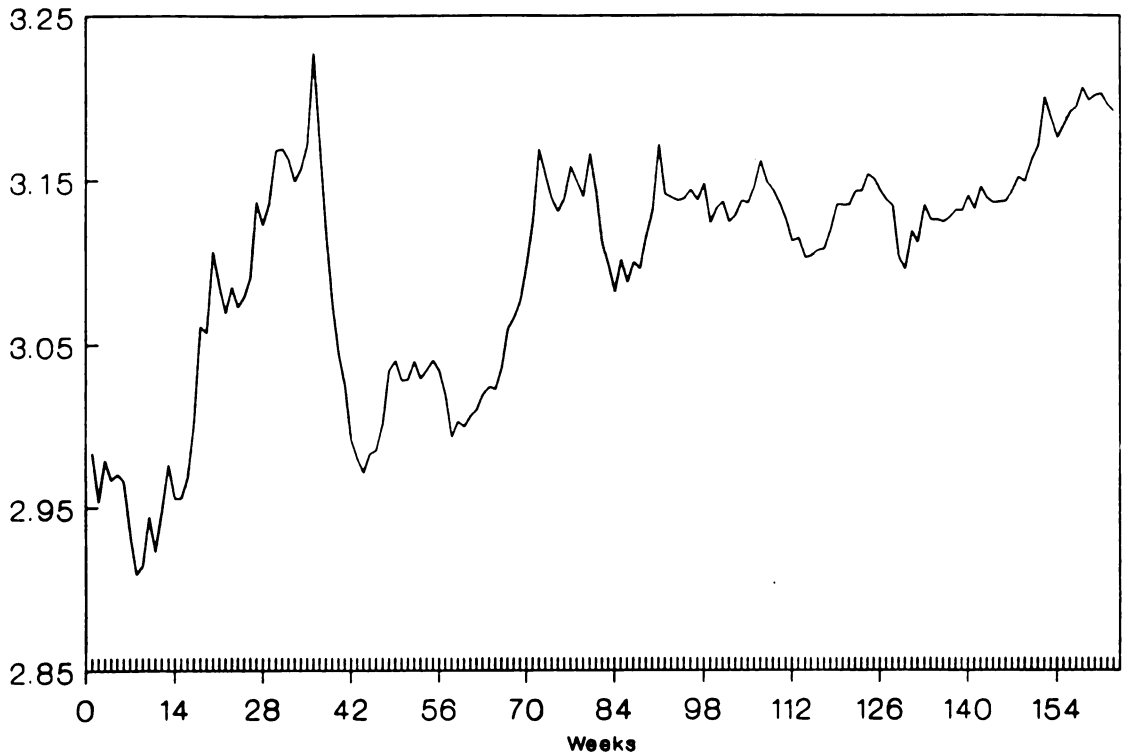


Figure 6
Log of the Weekly Swiss Spot Rate
February 1922 - April 1925

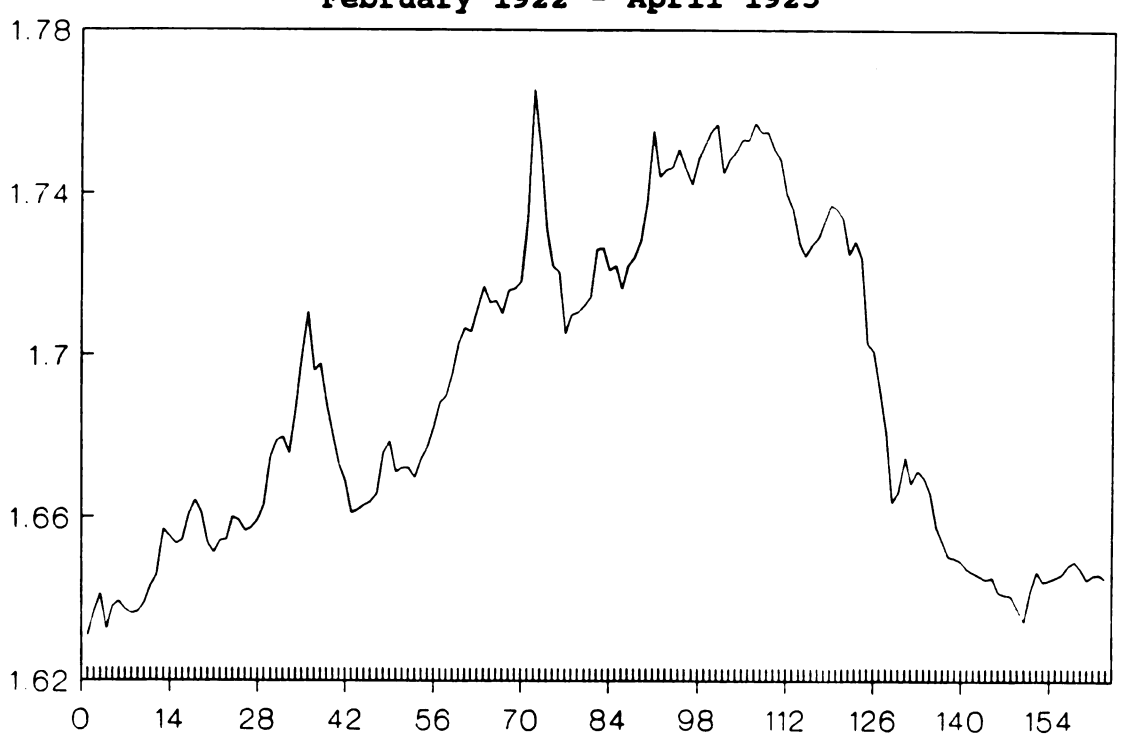


Figure 7
Belgian Rate of Return from Weekly Spot Rates
February 1922 - April 1925

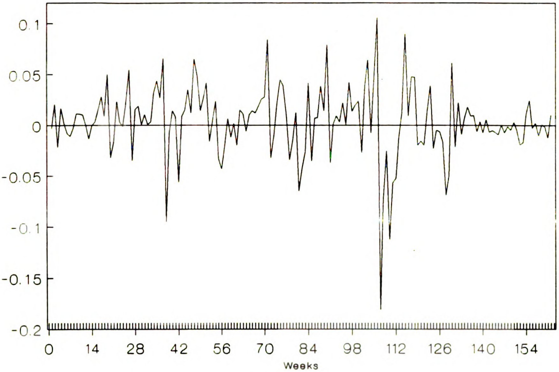


Figure 8
British Rate of Return from Weekly Spot Rates
February 1922 - April 1925

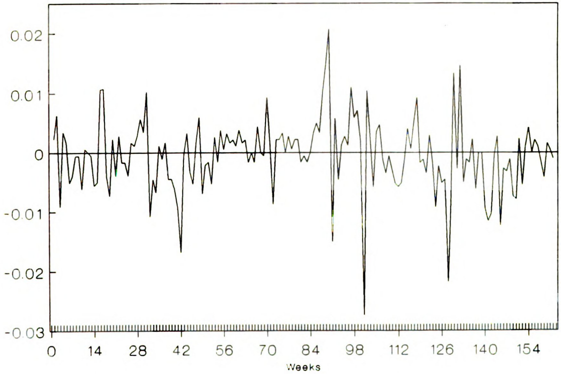


Figure 9
French Rate of Return from Weekly Spot Rates
February 1922 - April 1925

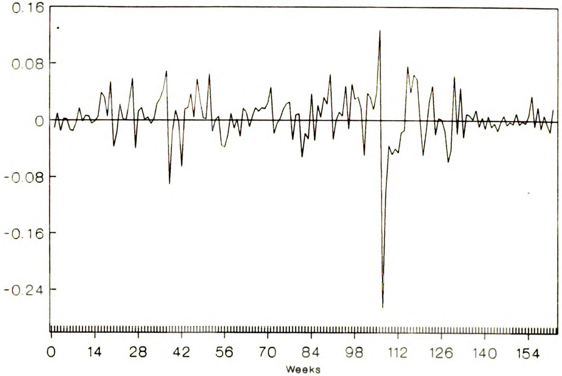


Figure 10
Dutch Rate of Return from Weekly Spot Rates
February 1922 - April 1925

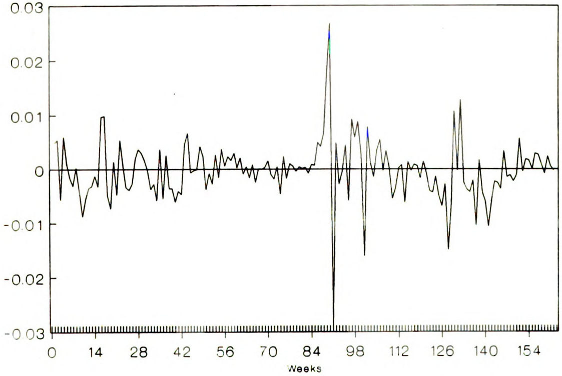


Figure 11
Italian Rate of Return from Weekly Spot Rates
February 1922 - April 1925

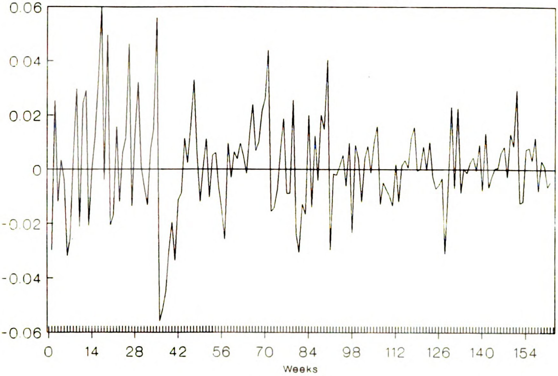
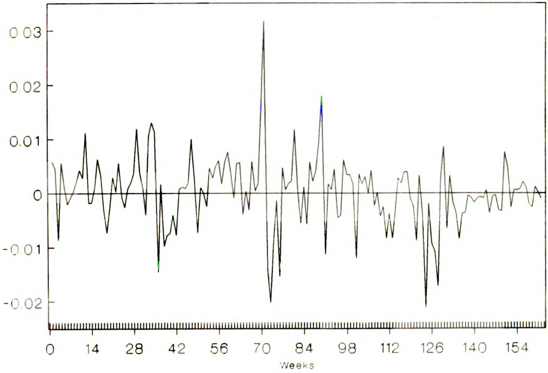
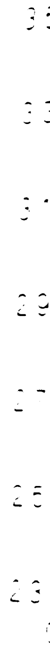


Figure 12
Swiss Rate of Return from Weekly Spot Rates
February 1922 - April 1925





Log

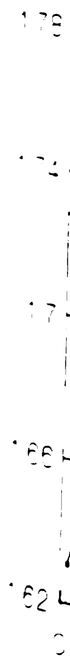


Figure 13
Log of the Belgian, French and Italian Spot Rates
February 1922 - April 1925

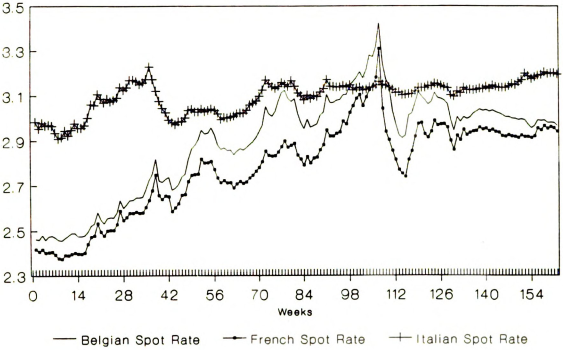


Figure 14
Log of the Swiss Spot Rate versus the 30-Day Forward Rate
February 1922 - April 1925

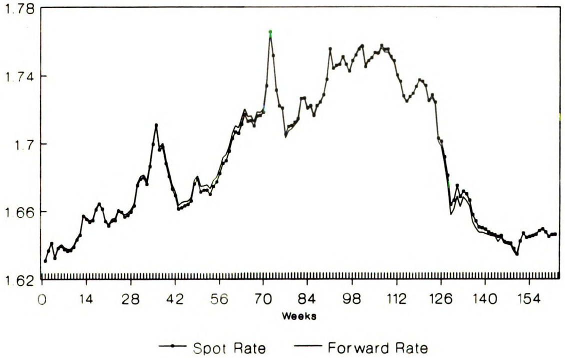


Figure 15
Belgian Conditional Variance versus Rate of Return
February 1922 - April 1925

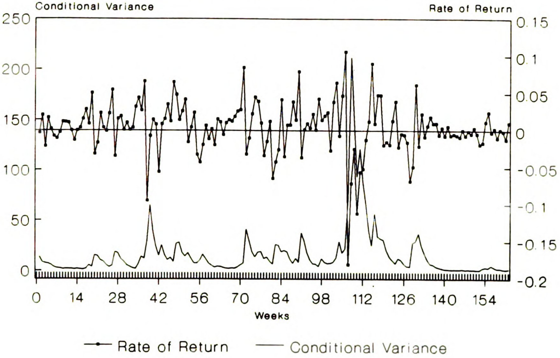


Figure 16
British Conditional Variance versus Rate of Return
February 1922 - April 1925

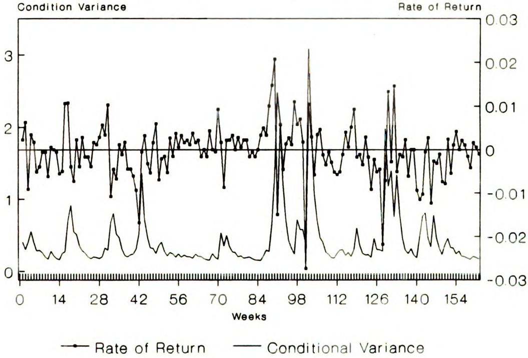


Figure 17
French Conditional Variance versus Rate of Return
February 1922 - April 1925

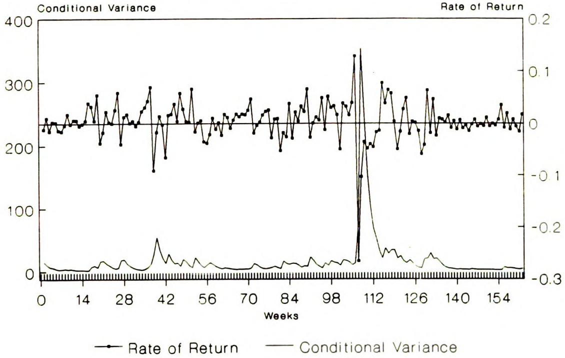


Figure 18
Dutch Conditional Variance versus Rate of Return
February 1922 - April 1925

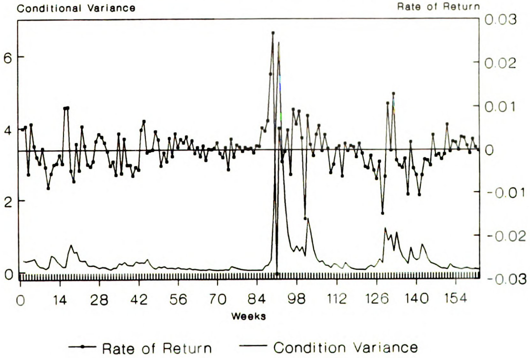


Figure 19
Italian Conditional Variance versus Rate of Return
February 1922 - April 1925

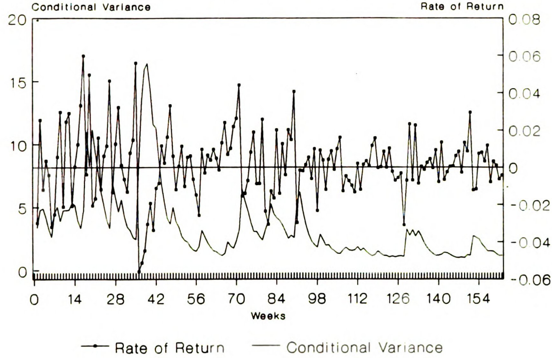
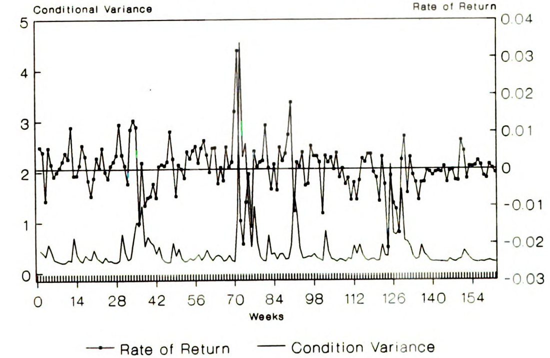


Figure 20
Swiss Conditional Variance versus Rate of Return
February 1922 - April 1925



LIST OF REFERENCES

LIST OF REFERENCES

Aliber, R. Z. (1962), "Speculation in the Foreign Exchanges: The European Experience, 1919-1926," Yale Economic Essays, 2, 171-245.

Bailey, Warren (1988), "Money Supply Announcements and the Ex Ante Volatility of Asset Prices," Journal of Money, Credit and Banking, 20, 611-620.

Baillie, Richard T. and Ralph Bailey (1985), "International Currency Speculation, Market Stability and Efficiency in the 1920s: A Time Series Approach," Journal of Macroeconomics, 6, 127-137.

Baillie, Richard T. and Tim Bollerslev (1989a), "Common Stochastic Trends in a System of Exchange Rates," The Journal of Finance, 44, 167-181.

Baillie, Richard T. and Tim Bollerslev (1989b), "The Message in Daily Exchange Rates: A Conditional Variance Tale," Journal of Business and Economic Statistics, 7, 297-305.

Baillie, Richard T. and Tim Bollerslev (1991), "Intra Day and Inter Market Volatility in Foreign Exchange Markets," Review of Economic Studies, 58, 565-585.

Baillie, Richard T. and Rowena A. Pecchenino (1991), "The Search for Equilibrium Relationships in International Finance: The Case of the Monetary Model," Journal of International Money and Finance, 10, 582-593.

Baxter, Marianne (1989), "Rational Response to Unprecedented Policies: The 1979 Change in Federal Reserve Operating Procedures," Mimeo, University of Rochester.

Berndt, E.K., B.H. Hall, R.E. Hall and J. Hausman (1974), "Estimation and Inference in Nonlinear Structural Models," Annals of Economic and Social Measurement, 4, 653-665.

Bollerslev, Tim (1986), "Generalized Autoregressive Conditional Heteroskedasticity," Journal of Econometrics, 31, 307-327.

Bollerslev, Tim (1988), "On the Correlation Structure for the Generalized Autoregressive Conditional Heteroskedastic Process," Journal of Time Series Analysis, 9, no. 2, 121-131.

Bollerslev, Tim ,Robert F. Engle and Jeffrey M. Wooldridge (1988), "A Capital Asset Pricing Model with Time-varying Covariances," Journal of Political Economy, 96, 116-131.

Boller
L
C

Chou,
S
E

Colema
F
2

Cook,
c
I
2

Corbae
F
2

Dickey
t
F
7

Dickey
T
U

Diebol
I
A

Dulles
T

The Ec

The Ec

Einzic
I

Einzic
Y

Engle,
E
I

Bollerslev, Tim and Jeffrey Wooldridge (1991), "Quasi-Maximum Likelihood Estimation of Dynamic Models with Time Varying Covariances," forthcoming Econometric Reviews.

Chou, Ray Y (1988), "Persistent Volatility and Stock Returns - Some Empirical Evidence Using GARCH," Journal of Applied Econometrics, 3, 279-294.

Coleman, Mark (1990), "Cointegration-Based Tests of Daily Foreign Exchange Market Efficiency," Economics Letters, 25, 53-59.

Cook, Timothy and Thomas Hahn (1988), "The Information Content of Discount Rate Announcements and Their Effect on Market Interest Rates," Journal of Money, Credit and Banking, 20, 167-180.

Corbae, Dean and Sam Ouliaris (1986), "Robust Tests for Unit Roots in the Foreign Exchange Market," Economic Letters, 22, 375-380.

Dickey, David A. and Wayne A. Fuller (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root," Journal of the American Statistical Association, 74, 427-431.

Dickey, David A. and Wayne A. Fuller (1981), "Likelihood Ratio Test Statistics for Autoregressive Time Series with a Unit Root," Econometrica, 49, 1057-1072.

Diebold, Francis X. and Marc Nerlove (1989), "The Dynamics of Exchange Rate Volatility: A Multivariate Latent Factor ARCH Model," Journal of Applied Econometrics, 4, 1-21.

Dulles, Eleanor (1929), The French Franc: 1914-1928, New York: The MacMillan Company.

The Economist (London) 7 January - 24 June 1922.

The Economist (London) 5 January - 28 June 1924.

Einzig, Paul(1937), The Theory of Forward Exchange, London: MacMillan and Company.

Einzig, Paul (1962), The History of Foreign Exchange, New York: St. Martin's Press.

Engle, Robert (1982), "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of U.K. Inflation," Econometrica, 50, 987-1008.

Engle, Robert and Tim Bollerslev (1986), "Modelling the Persistence of Conditional Variances," Econometric Reviews, 5, no.1, 1-50.

Engle, Robert, David M. Lilien and Russell P. Robins (1987), "Estimating Time Varying Risk Premia in the Term Structure: The ARCH-M Model," Econometrica, 55, 391-407.

Engle, Robert F., Takatoshi Ito and Wen-ling Lin (1990), "Meteor Showers or Heat Waves? Heteroskedastic Intra-Daily Volatility in the Foreign Exchange Market," Econometrica, 58, 525-542.

Fama, Eugene (1965), "The Behavior of Stock Market Prices," Journal of Business, 38, 34-105.

Fama, Eugene (1970), "Efficient Capital Markets: A Review of Theory and Empirical Works," Journal of Finance, 25, 383-417.

Fama, Eugene (1976), Foundations of Finance, Basic Books, New York.

Fama, Eugene (1991), "Efficient Capital Markets: II," journal of Finance, 46, 1575-1617.

Flood, Robert P (1981), "Explanations of Exchange-Rate Volatility and Other Empirical Regularities in Some Popular Models of the Foreign Exchange Market," In Policies for Employment, Prices, and Exchange Rates, K. Brunner and A. H. Meltzer, eds. Amsterdam: North-Holland, 219-250.

Frenkel, Jacob (1980), "Exchange Rates, Prices and Money: Lessons from the 1920's," American Economic Review, 70, 235-242.

Frenkel, Jacob (1981), "Flexible Exchange Rates, Prices, and the Role of 'News': Lessons from the 1920s," Journal of Political Economy, 89, 665-705.

Frenkel, Jacob and Kenneth Clements (1981), "Exchange Rates in the 1920's: A Monetary Approach," In Development in an Inflationary World, M. June Flanders and Assaf Razin eds., New York: Academic Press, 283-318.

Fuller, Wayne A. (1976), Introduction to Statistical Time Series, New York: Wiley.

Hamao, Yasushi, Ronald Masulis, and Victor Ng (1990), "The Effects of the Stock Market Crash on Financial Integration," Review of Financial Studies, 3, no. 2, 281-307.

Hein, S
t
o

Hodgso
R
E

Hoffma
o
D
3

Hsieh,
F
S

Johans
I
C
M
F

Kim, E
a

Kwiatk
Y
S
I
I
U

Lamour

C
S

Lastra
I
S

Ljung

MacDo

Mande

Hein, Scott (1985), "The Response of Short-term Interest Rates to Weekly Money Supply Announcements: A Comment," Journal of Money, Credit and Banking, 17, 264-270.

Hodgson, John S (1972), " An Analysis of Floating Exchange Rates: The Dollar-Sterling Rate, 1919-1925," Southern Economic Journal, 39, 249-257.

Hoffman, Dennis L. and Don E. Schlagenhauf (1985), "The Impact of News and Alternative Theories of Exchange Rates Determination," Journal of Money, Credit and Banking, 17, 328- 346.

Hsieh, D.A. (1989), "Modeling Heteroskedasticity in Daily Foreign-Exchange Rates," Journal of Business and Economic Statistics, 7, 307-317.

Johansen, Soren and Katarina Juselius (1989), "The Full Information Maximum Likelihood Procedure for Inference on Cointegration - with Applications," Institute of Mathematical Statistics, University of Copenhagen, Preprint #4 1-47.

Kim, Benjamin (1987), "Do Foreign Exchange Rates Really Follow a Random Walk?," Economics Letters, 23, 289-293.

Kwiatkowski, Denis, Peter C.B. Phillips, Peter Schmidt and Yongchoel Shin (1991), "Testing the Null Hypothesis of Stationarity Against the Alternative Hypothesis of a Unit Root: How Sure Are We that Time Series Contain a Unit Root?," Unpublished Manuscript, Michigan State University.

Lamoureux, Christopher E. and William D. Lastrapes (1990), "Persistence in Variance, Structural Change, and the GARCH Model," Journal of Business and Economic Statistics, 8, 225-241.

Lastrapes, William (1989), "Exchange Rate Volatility and U.S. Monetary Policy: An ARCH Application," Journal of Money, Credit and Banking, 21, 66-77.

Ljung, G. M. and G. E. P. Box (1978), "On a Measure of Lack of Fit in Time Series Models," Biometrika, 65, 297-303.

MacDonald, Ronald a,d Mark Taylor (1989), "Foreign Exchange Market Efficiency and Cointegration: Some Evidence from the Recent Float," Economics Letters,29, 63-68.

Mandelbrot, B. (1963), "The Behavior of Stock Market Prices," Journal of Business, 38, 34-105.

McFarl
D
D
3

Messe,
R
J

Moulto
S

Mussa,
C
M
E
9

New Yo

Newey
E
C

O'Bri

Pantu

Phill

Phill

Roley

Roley

Schir

McFarland, J.W., R.R. Pettit and S.K. Sung (1982), "The Distribution of Foreign Exchange Price Changes: Trading Day Effects and Risk Measurement," Journal of Finance, 37, 693-715.

Messe, Richard A. and Kenneth J. Singleton (1982), "On Unit Roots and the Empirical Modeling of Exchange Rates," Journal of Finance, 37, 1029-1035.

Moulton, Harold and Leo Pasvolsky (1929), World War Debt Settlements, The MacMillan Company, New York.

Mussa, Michael (1979), "Empirical Regularities in the Behavior of Exchange Rates and Theories of the Foreign Exchange Market," in The Cost and Consequences of Inflation, K. Brunner and A. H. Meltzer, eds. Amsterdam: North-Holland, 9-57.

New York Times (New York), 18 October-18 November, 1922.

Newey, W.K. and K.D. West (1987), "A Simple Positive Semi-Definite Heteroskedasticity and Autocorrelations Consistent Covariance Matrix," Econometrica, 55 703-708.

O'Brien, James M (1984), "The Information Value of the FOMC Policy Directive under the New Operating Procedures," Journal of Money, Credit and Banking, 16, 151-164.

Pantula, S.G. (1986), "Modelling the Persistence of the Conditional Variance: A Comment," Econometric Reviews, 5, 71-74.

Phillips, Peter C. B (1987), "Time Series Regression with a Unit Root," Econometrica, 55, 277-301.

Phillips, Peter C. B. and Pierre Perron (1988), "Testing for a Unit Root in Time Series Regression," Biometrika, 75, 335-346.

Roley, V. Vance (1983), "The Response of Short-term Interest Rates to Weekly Money Supply Announcements," Journal of Money, Credit and Banking, 15, 344-354.

Roley, V. Vance (1985), "The Response of Short-term Interest Rates to Weekly Money Supply Announcements: A Reply," Journal of Money, Credit and Banking, 17, 271-273.

Schirm, David C., Richard G. Sheehan and Michael G. Ferri (1989), "Financial Market Responses to Treasury Debt Announcements," Journal of Money, Credit and Banking, 21, 394-400.

Shepherd, Henry (1936), The Monetary Experience of Belgium, Princeton: Princeton University Press.

Shephton, Peter and Hans Larsen (1991), "Tests of Exchange Market Efficiency: Fragile Evidence from Cointegration Tests," Journal of International Money and Finance, 10, 561-570.

Urich, Thomas J (1982), "The Information Content of Weekly Money Supply Announcements," Journal of Monetary Economics, 10, 73-88.

Weiss, Andrew (1986), "ARMA Models with ARCH Errors," Journal of Time Series Analysis, 5, no. 2, 129-143.

Westerfield, J.M. (1977), "An Examination of Foreign Exchange Rate Rise Under Fixed and Floating Rate Regimes," Journal of International Economics, 7, 181-200.

White, H. (1982), "Maximum Likelihood Estimation of Misspecified Models," Econometrica, 50, 1-25.

Wooldridge, Jeffrey M (1990), "A Unified Approach to Robust Regression-Based Specification Tests," Econometric Theory, 6, no. 1, 17-43.

III. PURCHASING POWER PARITY AND THE DEMAND FOR MONEY IN THE 1920s

c

c

T

ex

pr

pos

be

excl

rela

made

appli

see *D*

(1982)

CHAPTER III

PURCHASING POWER PARITY AND THE DEMAND FOR MONEY IN THE 1920s

1. INTRODUCTION

Cassel (1916, 1918) focused attention on the Purchasing Power Parity (PPP) doctrine. Cassel believed monetary factors to be the most important long-run determinant of the exchange rate, though tariffs, transport costs, capital flows and expectations could also be important. In its absolute form, purchasing power parity states that the spot exchange rate, defined as the price of domestic currency in terms of foreign currency, adjusts to the ratio of domestic to foreign prices. The relative version of PPP equates changes in the spot exchange rate with changes in the ratio of domestic to foreign prices.

This concept, in either of its forms, presents two possible interpretations for PPP. Purchasing power parity can be thought of as a short-run theory of the determination of exchange rates, or alternatively as a long-run equilibrium relationship.

The assumption of purchasing power parity is routinely made when models of exchange rates are derived (for applications to sticky prices, monetary, and dynamic models see Dornbusch (1976), Frenkel and Johnston (1981), and Mussa (1982) respectively.) Many authors, however, Roll (1979),

u
f
w
o
19
Wa
an
te
are
evi
Lub

Rush
relat
of pp

Frenkel (1981), Darby (1983), and Hakkio (1984), find evidence that real exchange rates follow a random walk.

The failure of PPP to exist as a short-run phenomenon does not preclude its validity as a long-run equilibrium relationship. When PPP is viewed as a long-run concept, short-run departures are likely, but over time, these departures should disappear and the spot exchange rate should adjust to the ratio of relative prices (assuming PPP in its absolute form).

Table 1 contains recent empirical results on the existence of long-run PPP. The following observations can be made. Kim (1990a, 1990b) and Diebold, Husted, and Rush (1991) using annual data spanning several years find evidence favorable to PPP. This long-run relationship is more evident with wholesale prices than with consumer prices. The majority of the studies using quarterly or monthly data over the post 1973 float reject the existence of PPP except for McNoun and Wallace (1989) who analyze high inflation countries and Abuaf and Jorion (1990) who used multivariate techniques to analyze ten countries. Finally, the results pertaining to the 1920s are mixed. Frenkel (1980) and Taylor and McMahon (1988) find evidence favorable to PPP, whereas Enders (1988), Ardeni and Lubian (1989) and Ahking (1990) find evidence against.

The results from Table 1 are not surprising. Hakkio and Rush (1991) point out that cointegration tests of equilibrium relationships require long spans of data (hence the existence of PPP in long annual data sets and the relative sparsity

I
I
M
c
19
hy
co
al
exc
Feb
purs

using quarterly and monthly data). They also point out that the test results are difficult to interpret due to lack of power of the tests.

The period that is analyzed in this chapter is the 1920s. Table 1 indicates there is mixed support for the existence of PPP during this period. The 1920s is another time in this century when a whole system of exchange rates floated freely. It was considered an interim period between a war-enforced fixed exchange rate system and a proposed post-war fixed exchange rate system. The behavior of the exchange rates in the 1920s is very similar to that of the post 1973 system in that both periods are explained by martingale difference models, both contain time dependent heteroskedasticity, and foreign exchange markets appear relatively efficient.

During the 1920s, the spot exchange rates series and the price series are quite variable. In fact, the Belgian and French spot exchange rates depreciated approximately 80% from 1919 until these currencies were successfully stabilized. Most price levels, which had moved greatly during the war, continued to fluctuate after exchange controls were lifted in 1919. During the 1920s Germany experienced a severe hyperinflation and Shepherd (1936) suggests that economic conditions in France closely resembled that of hyperinflation, although the maximum monthly French inflation rate only exceeded nine percent during two months of this period, February 1923 and January 1924. Both Britain and Holland pursued domestic economic policies that were aimed at

p
a
me
a
th
us
pro
inf

gene
exis
3 th
analy

restoring pre-war convertibility levels of their exchange rates. The 1920s is a period which experienced many short-term monetary disturbances.

If purchasing power parity exists, it can be used to generate testable restrictions that can be imposed on a model. Consider, for example, the demand for money during high inflationary periods. Cagan (1956) developed a model in which the demand for real money balances are assumed to be inversely related to the rate of change of prices. Cagan assumed that agents formed inflationary expectations adaptively implying that expected inflation is a weighted sum of actual past prices.

This chapter examines the nature of the purchasing power parity relationship. The methodology which is employed uses a Maximum Likelihood technique due to Johansen (1988). This methodology tests for the number of long-run relationships in a vector of nonstationary I(1) variables as well as tests for the parameter values of these relationships. This study also uses the forward premium to proxy expected inflation; this proxy variable is used to explain the demand for money in high inflationary episodes.

The plan of the chapter is as follows. In section 2 the general time series properties of the data and tests for existence of purchasing power parity are presented. In section 3 the demand for money during high inflationary periods is analyzed. Section 4 contains the conclusions.

2. GENERAL TIME SERIES PROPERTIES AND THE EXISTENCE OF PURCHASING POWER PARITY

In this section, the existence of long-run purchasing power parity is examined for the following countries: Belgium, Britain, France, Germany, Holland, and the United States over the period 1921 - 1925.[1] The data on exchange rates comes from Einzig (1937) and represent the last quoted spot rate for each month. Price data come from two different sources: wholesale and retail price data come from Tinbergen (1934). For four countries, Britain, France, Germany, and the U.S., there also exists an additional price series published by the League of Nations.[2,3] Wholesale and retail prices are used since Table 1 indicates that long-run PPP appears more consistent with the use of wholesale prices, although there is some evidence consistent with the use of consumer prices.

The test procedure represents the trace test for the number of long-run equilibrium relationships from Johansen (1988). The test procedure is formally discussed in Appendix 2. A necessary condition for the Johansen procedure is that the variables be integrated of order one. If a linear

---

[1] The data period for Germany is 1921 - August 1923. The data set is truncated in August due to the severe hyperinflation that Germany experienced.

[2] Monthly Bulletin of Statistics 1921-1925.

[3] The retail price indices from Tinbergen (1934) are not the same for all countries. For Belgium and France the index is a general retail price index. The German index represents home goods. The British and Dutch indices measure retail food prices. The United States index measures finished goods prices.

combination of the variables is stationary, then long-run PPP exists.

Two tests for unit roots are employed. The first one is the Phillips-Perron tests developed by Phillips (1987) and Phillips and Perron (1988); the second test is due to Kwiatkowski, Phillips, Schmidt, and Shin (1991). The tests are formally described in section 2 of Chapter II.

Tables 2 and 3 contain the Phillips-Perron and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests for different bilateral exchange rates and price series. There is strong evidence that the monthly spot exchange rates are nonstationary. The German series displays some instability over the estimation period. The behavior of the monthly spot rates is similar to that of the weekly spot rates which are analyzed in Chapter II; in both cases the German spot rate appears explosive and Belgium, Britain, France, and Holland are nonstationary.

The behavior of the price series are similar. The German price series appear explosive. The Phillips-Perron and KPSS tests indicate that the wholesale, retail, and League of Nations price series are integrated of order one. The only disagreement between the two tests is the behavior of the U.S. price series; the KPSS test is unable to reject stationarity. Since the Phillips-Perron tests allow for more tests to be conducted and the power of these tests may be influenced by the small sample size, it is assumed that the U.S. series contain a unit root.

I

wh

ra

te

st

tha

bil

the

comb

curr

whol

vect

Tables 2 and 3 indicate that the monthly spot exchange rates and price series are integrated of the same order. It is, therefore, appropriate to use the Johansen methodology to investigate the existence of long-run purchasing power parity. The absolute version of PPP is

$$s_t = p_t - p^*_t \tag{3}$$

where s_t is the log of the spot exchange rate, p_t is the log of the domestic price level, and p^*_t is log of the foreign price level. This relationship can be rewritten as

$$s_t - p_t + p^*_t = \eta_t \tag{4}$$

where the quantity on the left hand side is the real exchange rate. Thus, testing for the existence of PPP is equivalent to testing that the errors in the real exchange rate equation are stationary.

Table 4 contains the results from the Johansen trace test that there exists r cointegrating vectors for all independent bilateral exchange rate/price series combinations. Since there are six countries, there are 15 independent combinations.

There exists at least one relationship between all currency combinations involving the United States when wholesale prices are used. There are two cointegrating vectors for the United States/Germany and United

States/Holland price and exchange rate combinations. There is one relationship between the United States and Britain over this sample period; this contrasts with Taylor and McMahon (1988), Ardeni and Lubian (1989) and Ahking (1990) who, using the Engle-Granger two-step method, are unable to find evidence of a long-run equilibrium relationship over this period although Taylor and McMahon were able to find one long-run relationship when the sample period was shortened by twelve months.

The use of retail prices yields similar results. The currency combinations involving the United States still exhibit a long-run relationship, although two relationships now exist between the United States and Britain. The United States/Britain relationship is the only one which exists for currency combinations involving the pound. Also, the relationships which emerge are in some instances different from those using wholesale prices. For instance, when Belgium is numeraire there are relationships between Britain, Holland, and the United States using wholesale prices, but France, Germany and the United States using retail prices. Foodstuffs data from the League of Nations yield no long-run equilibrium relationships.

One possible interpretation of multiple cointegrating vectors is the existence of an informal monetary system. Under this possibility, there is a long-run relationship toward which the system would gravitate on its own; there exists another long-run relationship which the countries are trying to force the system to attain. In fact, the Genoa conference in 1922 specified that Europe should return to the Gold standard as soon as possible at pre-war parity levels.

One further hypothesis can be tested for those countries that exhibit a single long-run relationship. Equation (4) is a specific example of the more general specification

$$s_t = ap_t + bp^*_t + \eta_t \tag{5}$$

with the values of a and b being 1, -1 respectively. This often assumed hypothesis implies that if both the domestic and foreign price levels move by the same percentage amounts, the spot exchange rate will remain unchanged.

This hypothesis can be tested in two ways. First, the parameter values of the cointegrating vector can be constrained to equal the hypothesized values. A likelihood ratio test statistic is formed which is distributed as χ^2_m where m is the number of restrictions when the number of cointegrating vectors is one. The second procedure involves unit root tests on bilateral exchange rate combinations.

Table 5 contains the Likelihood Ratio Statistics for the hypothesis that when r=1 the coefficient on the spot rate is 1, the coefficient on the domestic price level is 1, and the coefficient on the foreign price level is -1. In no situation can the hypothesis be rejected that the coefficients in the cointegrating vector are 1, 1, -1. Table 6 contains Phillips-Perron and KPSS tests for the real exchange rates for the fifteen bilateral rate combinations. Both tests indicate that real exchange rates are nonstationary. Thus, the Johansen methodology, Phillips-Perron tests and KPSS tests yield conflicting evidence on the properties of the purchasing power parity relationship. The difference is possibly due to the lower power of these tests when the sample size is small. In section three, the existence of PPP is assumed.

3. MONEY DEMAND AND PURCHASING POWER PARITY

In this section, the Purchasing Power Parity results from the previous section are used in the analysis of the demand for money for the countries previously analyzed. The United States is chosen as the numeraire since previous results indicate similar behavior with other currency combinations and the United States was a relatively stable numeraire. As previously mentioned, Britain and Holland undertook specific deflationary policies to force the spot exchange rate to return to the pre-war convertibility level, while Belgium and France underwent extreme currency depreciation and experienced a potential monetary collapse with high rates of inflation, and Germany endured a severe hyperinflation.

Cagan (1956) estimated the demand for real money balances during hyperinflationary times as

$$\ln(M/P)_t = \gamma + a\pi^e_t + \epsilon_t \tag{6}$$

r

e

a

pr

va

cu

Fr

the

How

bas

Ger

ign

infl

where M/P are real money balances, π^e are inflationary expectations and ϵ_t is a serially uncorrelated error term. Cagan used a least squares procedure which maximized the total correlation coefficient and found real money balances to be inversely related to expected inflation, when measured as a weighted sum of past inflation rates.

Many authors have extended Cagan's analysis of the German hyperinflation (see, Sargent and Wallace (1973), Frenkel (1977), Sargent (1977), Evans (1978), Salemi (1979), Frenkel (1979), Abel, Dornbusch, Huizinga and Marcus (1979), Salemi (1980a), Salemi (1980b), Desai and Keil (1986), Burmeister and Wall (1987) and Christiano (1987)). One theme that researchers analyze is how to measure inflationary expectations.

Cagan argues for the actual rate of inflation. Abel et al. (1979) show that the actual rate can be used if it is a proxy for true expectations but measured with error. Another variable that Abel et al. suggest is the rate of expected currency depreciation as measured by the forward premium. Frenkel (1977,1979) had previously argued for the inclusion of the forward premium in the German money demand function. However, Salemi (1980a) showed that inflationary expectations based solely on the forward premium were not rational in Germany; by November 1922 the forward premium systematically ignored information in the past history of the rate of inflation. Salemi (1980b) showed that expected currency w

n

th

or

wher

depreciation, measured as the first difference of the spot exchange rate, did not influence the demand for money during the German hyperinflation.

Suppose PPP does hold as a long-run relationship. Then

$$\ln s_t = \ln P_t - \ln P_t^* + \epsilon_t \tag{7}$$

where s = the spot exchange rate, P = the domestic price level, and P^* = the foreign price level, and ϵ_t is an equilibrium error. If it were possible to observe

$$E_t \ln s_{t+1} = E_t \ln P_{t+1} - E_t \ln P_{t+1}^* \tag{8}$$

where s_{t+1} is next period's spot rate and P_{t+1} and P_{t+1}^* are next period's domestic and foreign price level respectively, then

$$\ln s_t - E_t \ln s_{t+1} = (\ln P_t - E_t \ln P_{t+1}) - (\ln P_t^* - E_t \ln P_{t+1}^*) + \eta_t, \tag{9}$$

or

$$E_t(\ln P_{t+1} - \ln P_t) = (E_t \ln s_{t+1} - \ln s_t) + \mu_t + \eta_t \tag{10}$$

where

$$\mu_t = (\ln P_t^* - E_t \ln P_{t+1}^*) \tag{11}$$

s

m

i

fr

cu

an

de

app

of

yie

is the expected inflation in the foreign country and η_t is a serially uncorrelated error term with $E(\eta_t) = 0$. If inflation is relatively moderate in the foreign country, then the rate of domestic inflation is determined by the rate of currency depreciation.

If the future spot rate equals the forward rate plus a random error term, then

$$s_{t+1} = f_t + \xi_{t+1} \tag{12}$$

where s_{t+1} is the spot rate in time t+1, f_t is the forward rate and ξ_{t+1} is a random error term. However, equation (12) suffers from the Siegal (1972) paradox; for purely mathematical reasons, if the forward price of foreign currency in terms of domestic currency equals the expected anticipated future spot rate, then the forward price of the domestic currency cannot equal the expected value of the corresponding anticipated future spot rate. McCulloch (1975) has demonstrated that this paradox is not relevant in empirical applications; this study employs a log-linear specification of equation (12).

Taking expectations and substituting into equation (10) yields

$$\pi_t^e = \ln f_t - \ln s_t + \mu_t + \eta_t \tag{13}$$

e

a

f

wh

no

inr

Ger

exc

var

expe

where π_t^e is expected inflation, $\ln f_t - \ln s_t$ is the forward premium and the other variables are defined as above. The existence of PPP implies that the forward premium can be a measure of expected inflation if foreign inflation is relatively stable.

Cagan (1956 p.91) observed that extreme short-term changes in exchange rates primarily reflect variations in the real value of the currency. The public might expect the depreciation of the currency to manifest itself more accurately in depreciation of exchange rates rather than changes in prices since exchange rate data are observed more frequently. But real cash balances would be related to exchange rate depreciation only as long as it remains an accurate indicator of price changes. The model for the demand for real balances is

$$\ln(M/P)_t = \alpha + \beta(\ln f_t - \ln s_t) + \zeta_t$$

where $\ln f_t - \ln s_t$ is the forward premium and ζ_t is a white noise error term.

This model should be an adequate description for the high inflation/hyperinflation countries of Belgium, France, and Germany since there are extreme movements in their foreign exchanges. British and Dutch foreign exchanges show less variability than the other countries and this model should be expected to perform less satisfactorily.

The forward exchange rate data comes from Einzig (1937) and represents the quotation nearest the end of the month. The money supply data and the price data come from Tinbergen (1934) and the Monthly Bulletin of Statistics published by the League of Nations. The price series are described in section 2 and the money supplies are the sum of currency outstanding and deposits.

Table 7 contains the Phillips-Perron tests for real money balances when both wholesale prices and retail prices are used, the 30-day forward rate, and the forward premium. British and Dutch real money balances are stationary using wholesale prices. Germany and Belgium are nonstationary. The results for France are mixed.[4] For real money balances using retail prices, the results are similar except that Belgian real money balances behave in a similar manner to the French balances. The 30-day forward exchange rates are all I(1). The forward premium is stationary in all cases except for Germany.

The behavior of the British, Dutch and German monthly forward premiums are in contrast to the behavior of the weekly forward premiums analyzed in Chapter II; the weekly forward premiums for Britain and Holland were nonstationary, whereas

---

[4] KPSS tests were performed for all series. The KPSS tests for real money balances using wholesale prices indicate that Britain, France and Holland are stationary where as Germany is nonstationary. Also, Belgium appears stationary. The same conclusions hold for real money balances when retail prices are used. The forward rates are nonstationary and the forward premiums are stationary with the exception of Germany which is nonstationary.

Germany was stationary. Table 8 contains KPSS tests and autocorrelation functions for the monthly forward premiums. The autocorrelation functions decline rapidly for Britain and Holland; for Germany the function declines more slowly. The unit root tests indicate Britain and Holland are stationary, and Germany is nonstationary.

Table 9 contains the money demand results for Belgium, Britain, France, and Holland. The coefficients for Belgium and France both have a negative sign and are significant at the 5% critical level indicating that a depreciation of the currency as measured by the forward premium results in a decrease in the demand for real money balances. These two countries are the ones that experienced high levels of inflation. For both the British and Dutch equations, the forward premium is not statistically significant and is of the wrong sign. However, there is evidence of autocorrelation for Belgium, Britain, and France.

Table 10 contains the results for the money demand equations when a first order Cochrane-Orcutt correction is used. The correction for autocorrelation changes the signs on all the estimated coefficients of the forward premium; the Belgian and French coefficients are now positive, while the British coefficient is negative. In no case is the forward premium statistically significant.

One possible reason for the poor performance of the above regressions is the absence of real income from the list of explanatory variables. Actual real income data are scarce,

i
r
i
r

in
fo
Br

co
tha
rea

but for two countries, Britain and France, a proxy does exist. The French real income data is the General Index of Industrial Production from Tinbergen (1934). The British data are taken from Frenkel and Clements (1981) who generate monthly real income data by interpolating annual industrial production using the monthly unemployment series. Table 11 contains the results for the inclusion of the log of real income in the demand for money equation for Britain and France when the Cochrane-Orcutt correction for autocorrelation is used.

When wholesale prices are used, the forward premium has a negative sign for France, but a positive sign for Britain. Neither coefficient is statistically significant. Interestingly, the income variable takes on a negative sign for both Britain and France and is statistically significant in the French equation. This negative coefficient could indicate that during high inflationary periods, an increase in real income leads to a decrease in the demand for money and an increase in the demand for some commodity which is a relatively stable store of value.

The results for retail prices are similar. The French income measure is negative and statistically significant. The forward premium is negative in the French and positive in the British equations, although neither is significant.

Table 12 contains the Johansen trace test for cointegration for German real balances. The null hypothesis that there exists a long-run equilibrium relationship between real balances and the forward premium when both wholesale

a
c
m
r
lo
pr

re
ana
ret

prices and retail prices are used to determine real balances can be rejected. Thus, the forward premium does not help determine the equilibrium level of real balances.

4. CONCLUSIONS

This study attempts to characterize the behavior of the monthly spot rates and the monthly price indices in the 1920s period, investigates the empirical validity of the Purchasing Power Parity relationship in its absolute form, and examines the use of Purchasing Power Parity for generating economic variables for the demand for money function.

Tests for the existence of PPP are carried out using the Johansen trace test for all independent bilateral exchange rate and price combinations for the countries of Belgium, Britain, France, Germany, Holland, and the United States. This test allows the number of long-run relationships to be tested. Using both wholesale prices and retail prices, there appears to be a long-run relationship between most of the countries tested. For some countries, there is evidence of more than one long-run relationship to which the exchange rate/price combinations can move. There is no evidence of a long-run relationship from any bilateral test when retail prices collected by the League of Nations are used.

The results indicate the existence of PPP as a long-run relationship. Furthermore, for some of the countries analyzed, it does not matter which price level (wholesale or retail) is chosen.

c
N
r

co
fo
Th
co
on
sig
deg.
to

One further test is employed concerning the PPP relationship. A regularly assumed hypothesis is that the coefficients on the domestic and foreign price levels are unity and minus unity respectively. For all bilateral exchange rate/price combinations which exhibited a single long-run relationship, the null hypothesis of unity and minus unity cannot be rejected. Thus an equal percentage movement in domestic and foreign prices does not lead to a change in the spot exchange rate. However, tests of real exchange rates indicate that they are nonstationary. This contradicts the results from using the Johansen (1988) methodology.

The existence of multiple long-run relationships complicates the interpretation and the usefulness of the PPP doctrine as a policy guide. The problem for the policy maker is not knowing which cointegrating vector the system is operating under if there is more than one vector. Nonetheless, the system is moving to some long-run relationship.

When analyzing the demand for money for high inflation countries, the imposition of PPP leads to the inclusion of the forward premium as a measure of inflationary expectations. The preliminary tests show that for the two high inflation countries, Belgium and France, the signs on the coefficients on the forward premium are the negative but not statistically significant. However, the results are influenced by a high degree of autocorrelation. Correction for this problem leads to the coefficient on the forward premium to enter with a positive and insignificant sign for Belgium and France, and a negative and insignificant sign for Britain. Further analysis using income variables for Britain and France shows that the forward premium has the required sign for France, but is not statistically significant.

Both German real balances and the forward premium are integrated of order one. Thus, the possibility exists that there is a long-run equilibrium relationship between these variables. A test for this equilibrium relationship fails to find any evidence. Thus, the forward premium and the level of real money balances do not seem to move together over time.

This general lack of relationship between the forward premiums and the levels of real balances is disappointing, but perhaps not unexpected for these series. The data series are very short. The maximum number of useable observations is fifty-two. This sparsity of data could influence the estimation of the money demand function.

Also, it is possible that if the country is attempting to either fix its exchange rate or force its exchange rate to a specified level that the money supply process is linked to exchange rate fluctuations or expectations of exchange rate fluctuations. In this situation, estimation of the money demand equation is contaminated by the money supply effect which invalidates the results.

While the data sets are very short for the 1920s period, there have been recent high inflation episodes. The existence of these episodes implies that this idea can be extended in two areas. The first is whether PPP holds for these high inflation countries. The second is, in the case where PPP does hold, whether the forward premium provides an adequate proxy for the level of expected inflation.

TABLE 1

Summary of Purchasing Power Parity Results

Author	Sample Period	Countries Examined	Methodology	Results
Frenkel (1980)	1921.2–1925.5[*,w]	BR,FR,GR,	REGAR	PPP
Adler & Lehman (1983)	1964.1–1981.5[c]	**	REGF	Martingale
	1900–1972[w,+]	BR,CN,FR, GR,HL,IT, JP,SW		Martingale
Baillie & Selover (1987)	1973.1 – 1983.12[c]		EG2	no PPP
Rush & Husted (1985)	1954.I – 1982.IV[c]	BR,CN,FR, GR,IT,JP, SW	LowFreq	PPP[d]
Corbae & Ouliaris (1988)	1973.7–1986.9[c]	BR,CN,GR, IT	EG2	no PPP
Enders (1988)	1960.1–1971.4[w]	CN,GR,JP,	EG2	JP/US
	1973.1–1986.11[w]			CN/US
Taylor (1988)	1973.6–1985.12[m]	BR,CN,FR, GR,JP	EG2	no PPP
Taylor & McMahon (1988)	1921.2–1925.5[*,w]	BR,FR,GR,	EG2	PPP
Ardeni & Lubian (1989)	1921.2–1925.5[*,w]	BR,FR,GR,	EG2	no PPP
Karfakis & Moschos (1989)	1975.I–1987.I[w]	BR,FR,IT, JP,GE,GR	EG2	no PPP

TABLE 1 (cont'd)

McNoun & Wallace (1989)	1976.1-1986.6***	AG,BZ,CH, IS	EG2	PPP[w]
Abuaf & Jorion (1990)	1900-1972[w]	BL,BR,CN, FR,GR,IT, JP,HL,NW, SW	DFSURE	PPP
	1973.1-1987.12[c]			MPPP
Ahking (1990)	1921.2-1925.5[w]	BR	EG2	no PPP
Kim (1990a)	1900-1987[w]	BR,CN,IT, JP	EG2/JJ	PPP
	1914-1987[c]			no PPP
Kim (1990b)	1900-1987[w]	BR,CN,IT, JP	EG2	PPP
	1914-1987[c]			no PPP
Mark (1990)	1973.6-1988.2[c]	BL,BR,CN, FR,GR,JP, IT	EG2	no PPP
Diebold, Husted & Rush (1991)	1791-1913++	BL,BR,FR, GR,SD	ARFIMA	PPP
Baillie & Pecchinino (1991)	1973.3-1990.5[c]	BR	KPSS/PP/ ARFIMA	near unit root

w represents the wholesale price index
c represents the consumer price index
* For Germany, the sample period is 1921.1 - 1923.8.
+ 1915 - 1972 CPI
** There are twenty-two countries examined: AG, AS, BL, BR, BZ, CN, CH, DN, FR, GR, HL, IN, IR, IS, IT, JP, MX, NW, SA, SD, SW and VN.

TABLE 1 (cont'd)

d When the U.S. is numeraire, PPP is found to hold for all bilateral exchange rate combinations. However, when Britain, France and Germany are used, PPP is rejected for all independent currency combinations.

m represents manufacturing price index

*** The actual samples are: AR 1976.1 - 1986.6 (CPI), 1976.1 - 1985.3 (WPI); BZ 1976.3 - 1986.2 (CPI,WPI); CH 1972.8 - 1979.12 (CPI), 1972.1 - 1979.12 (WPI); IS 1976.1 - 1985.12 (CPI,WPI).

++ The actual samples are: BL 1832 - 1913 (WPI), 1835 - 1913 (CPI); FR 1806 - 1913 (WPI), 1840 - 1913 (CPI); GR 1792-1913 (WPI), 1820 - 1913 (CPI); SD 1830_1913 (CPI); BR 1798 - 1913 (WPI); and US 1791 - 1913 (WPI).

Key: All exchange rates are in terms of U.S. dollars. AG = Argentina, BL = Belgium, BR = Britain, BZ = Brazil, CN = Canada, CH = Chile, DN = Denmark, FR = France, GE = Greece, GR = Germany, HL = Holland, IN = Indonesia, IR = Iran, IS = Israel, IT = Italy, JP = Japan, MX = Mexico, NW = Norway, SA = South Africa, SD = Sweden, SW = Switzerland, VN = Venezuela, and US = United States.

EG2 = Engle-Granger two-step method.

DFSURE = Dickey Fuller tests are extended to a system of univariate autoregressions estimated jointly in a Seemingly Unrelated Regression framework.

LosFREQ = A decomposition of the data into a low-frequency trend component and a high-frequency noise component. The trends are used in distributed lag regressions to test for PPP.

REGF = F tests based on regressions estimating the real exchange rate.

REGAR = OLS regression with correction for autocorelation.

JJ = Johansen-Juselius methodology.

ARFIMA = Autoregressive Fractionally Integrated Moving Average model.

KPSS = Kwiatkowski, Phillips, Schmidt and Shin tests.

PP = Phillips-Perron tests.

LowFreq = testing low frequency components.

PPP indicates evidence favorable to Purchasing Power Parity.

MPPP indicates marginal evidence.

No PPP indicates that the real exchange rate appears nonstationary.

Martingale refers to the Martingale model.

TABLE 2

Phillips-Perron Tests

Monthly Spot Exchange Rates 1921.1-1925.5

Belgium Numeraire

	Britain	France	Germany*	Holland	U.S.
$z(t_{\hat{\alpha}})$	1.350	-0.890	3.106	1.149	0.823
$z(t_{\alpha^*})$	-0.768	-1.969	2.485	-0.884	-0.967
$z(\Phi_1)$	1.465	2.204	5.642	1.404	1.009
$z(t_{\tilde{\alpha}})$	-1.622	-0.401	1.361	-1.497	-1.705
$z(\Phi_2)$	2.220	1.835	5.581	1.979	1.621
$z(\Phi_3)$	1.710	2.686	4.138	1.632	1.786

Britain Numeraire

	France	Germany	Holland	U.S.
$z(t_{\hat{\alpha}})$	1.367	2.791	0.920	1.139
$z(t_{\alpha^*})$	-0.159	2.413	-0.975	-1.231
$z(\Phi_1)$	1.080	5.295	1.220	1.695
$z(t_{\tilde{\alpha}})$	-2.525	1.255	-1.574	-1.670
$z(\Phi_2)$	4.095	5.371	1.852	1.760
$z(\Phi_3)$	4.997	4.031	2.164	1.510

TABLE 2 (cont'd)

France Numeraire

	Germany*	Holland	U.S.
$z(t_{\hat{\alpha}})$	3.131	1.206	0.785
$z(t_{\alpha^*})$	2.497	-0.314	-0.608
$z(\Phi_1)$	5.711	1.000	0.644
$z(t_{\tilde{\alpha}})$	1.393	-2.463	-2.295
$z(\Phi_2)$	5.654	3.889	2.844
$z(\Phi_3)$	4.128	4.976	3.842

Germany Numeraire*

	France	Holland
$z(t_{\hat{\alpha}})$	2.926	2.836
$z(t_{\alpha^*})$	2.399	2.408
$z(\Phi_1)$	5.230	5.263
$z(t_{\tilde{\alpha}})$	1.244	1.276
$z(\Phi_2)$	5.320	5.243
$z(\Phi_3)$	3.993	4.018

Holland Numeraire

	U.S.
$z(t_{\hat{\alpha}})$	-1.081
$z(t_{\alpha^*})$	-1.514
$z(\Phi_1)$	1.787
$z(t_{\tilde{\alpha}})$	-1.627
$z(\Phi_2)$	1.535
$z(\Phi_3)$	1.583

TABLE 2 (cont'd)

Wholesale Price Index

	Belgium‡	Britain	France	Germany*	Holland	U.S.
$z(\hat{t}_\alpha)$	1.289	-1.592	0.690	2.573	-1.667	-0.589
$z(t_\alpha^*)$	-1.309	-5.333	-0.336	3.060	-4.344	-3.469
$z(\Phi_1)$	1.853	15.419	0.336	7.908	10.552	7.791
$z(\tilde{t}_\alpha)$	-1.013	-4.690	-3.721	1.846	-4.111	-4.795
$z(\Phi_2)$	1.572	10.763	5.771	7.018	7.695	8.902
$z(\Phi_3)$	1.083	13.698	8.546	6.190	10.469	13.023

Retail Prices

	Belgium	Britain	France	Germany*	Holland	U.S.
$z(\hat{t}_\alpha)$	0.421	-1.625	0.036	1.356	-1.401	-0.961
$z(t_\alpha^*)$	-0.620	-3.547	-1.331	0.894	-2.368	-5.052
$z(\Phi_1)$	0.315	7.421	0.905	1.381	3.859	12.584
$z(\tilde{t}_\alpha)$	-3.530	-2.916	-4.029	-0.272	-1.732	-4.457
$z(\Phi_2)$	5.141	5.162	7.318	2.122	2.601	8.820
$z(\Phi_3)$	7.678	6.440	10.999	1.825	2.922	12.493

TABLE 2 (cont'd)

Retail Prices

League of Nations

	Britain	France	Germany*	U.S.
$z(t_{\hat{\alpha}})$	-1.724	0.036	2.662	-0.811
$z(t_{\alpha^*})$	-3.547	-1.332	2.899	-4.529
$z(\Phi_1)$	7.421	0.906	6.930	10.810
$z(t_{\tilde{\alpha}})$	-2.916	-4.196	2.207	-4.469
$z(\Phi_2)$	5.162	7.820	5.991	8.750
$z(\Phi_3)$	6.440	11.756	5.566	12.706

* 1921.1-1923.8
\# 1921.8-1925.5

Key: The 5% critical values for $z(t_{\hat{\alpha}})$, $z(t_{\alpha}^{*})$ and $z(t_{\tilde{\alpha}})$ are -1.95, -2.86, and -3.41 respectively. The 95% significance level for $z(\Phi_1)$, $z(\Phi_2)$ and $z(\Phi_3)$ are 4.59, 4.68 and 6.25 respectively.

TABLE 3

Kwiatkowski, Phillips, Schmidt and Shin Tests

Monthly Spot Rates

Belgium Numeraire

No Trend

	k=4	k=6
BR	1.045	0.773
FR	0.530	0.411
GR*	0.718	0.561
HL	1.033	0.764
US	0.951	0.706

Trend

	k=4	k=6
BR	0.174	0.139
FR	0.253	0.202
GR	0.200	0.171
HL	0.176	0.142
US	0.141	0.113

TABLE 3 (cont'd)

Britain Numeraire

No Trend

	k=4	k=6
FR	1.072	0.799
GR*	0.715	0.558
HL	0.469	0.439
US	0.708	0.550

Trend

	k=4	k=6
FR	0.114	0.101
GR*	0.200	0.171
HL	0.068	0.068
US	0.169	0.136

France Numeraire

No Trend

	k=4	k=6
GR*	0.719	0.562
HL	1.061	0.789
US	0.945	0.707

Trend

	k=4	k=6
GR*	0.200	0.171
HL	0.118	0.106
US	0.135	0.113

TABLE 3 (cont'd)

Germany Numeraire*

No Trend

	k=4	k=6
HL	0.715	0.558
US	0.712	0.556

Trend

	k=4	k=6
HL	0.200	0.171
US	0.200	0.170

Holland Numeraire

No Trend

	k=4	k=6
US	0.653	0.510

Trend

	k=4	k=6
US	0.171	0.140

TABLE 3 (cont'd)

Monthly Wholesale Prices

No Trend

	K=4	K=6
BL∓	0.894	0.664
BR	0.530	0.416
FR	0.989	0.737
GR*	0.709	0.551
HL	0.806	0.627
US	0.182	0.157

Trend

	k=4	k=6
BL	0.164	0.133
BR	0.259	0.202
FR	0.167	0.139
GR*	0.205	0.171
HL	0.265	0.214
US	0.079	0.070

TABLE 3 (cont'd)

Monthly Retail Prices

No Trend

	k=4	k=6
BL	0.902	0.668
BR	0.736	0.576
FR	0.681	0.525
GR*	0.559	0.487
HL	0.674	0.523
US	0.274	0.236

Trend

	k=4	k=6
BL	0.227	0.179
BR	0.245	0.196
FR	0.251	0.205
GR*	0.098	0.095
HL	0.257	0.204
US	0.118	0.102

TABLE 3 (cont'd)

Monthly Retail Prices

League of Nations

No Trend

	k=4	k=6
BR	0.736	0.576
FR	0.694	0.533
GR*	0.694	0.541
US	0.200	0.178

Trend

	k=4	k=6
BR	0.245	0.196
FR	0.251	0.206
GR*	0.206	0.170
US	0.193	0.171

* 1921.1-1923.8
≠ 1921.8-1925.5

Key: The 5% critical values for the KPSS tests are 0.146 when a trend term is included in the regression and 0.462 when only a constant is included in the regression; k represents the number of lags in the residual series.

TABLE 4

Johansen Trace Test for Cointegration

Belgium Numeraire

Wholesale Prices[‡]

	r=0	r≤1	r≤2
BR	39.466	20.134	5.147
FR	18.795	6.743	1.612
GR	---	---	---
HL	43.029	12.523	2.479
US	49.477	12.309	1.741

Retail Prices

	r=0	r≤1	r≤2
BR	26.044	12.604	3.408
FR	37.911	19.745	6.894
GR	39.266	6.152	2.198
HL	27.762	10.305	2.301
US	29.899	12.528	1.767

TABLE 4 (cont'd)

Britain Numeraire

Wholesale Prices

	r=0	r≤1	r≤2
FR	35.210	14.584	4.362
GR	24.837	10.100	2.036
HL	27.745	7.056	1.513
US	31.728	14.853	6.070

Retail Prices

	r=0	r≤1	r≤2
FR	26.847	11.355	2.445
GR	25.892	4.847	0.131
HL	26.334	12.784	4.644
US	47.698	20.555	8.361

Retail Prices - League of Nations

	r=0	r≤1	r≤2
FR	28.191	12.308	2.823
GR	19.385	8.884	2.588
US	27.329	15.446	4.620

TABLE 4 (cont'd)

France Numeraire

Wholesale Prices

	r=0	r≤1	r≤2
GR	20.528	10.490	4.348
HL	36.304	11.193	1.144
US	31.443	7.951	0.167

Retail Prices

	r=0	r≤1	r≤2
GR	39.085	9.164	0.880
HL	28.475	11.082	2.083
US	29.134	15.154	1.659

Retail Prices - League of Nations

	r=0	r≤1	r≤2
GR	25.731	12.740	5.719
US	25.364	12.148	0.812

Germany Numeraire

Wholesale Prices

	r=0	r≤1	r≤2
HL	29.079	10.690	4.483
US	29.104	16.336	6.287

TABLE 4 (cont'd)

Retail Prices

	r=0	r≤1	r≤2
HL	33.262	9.673	0.683
US	37.794	16.876	0.743

Retail Prices - League of Nations

	r=0	r≤1	r≤2
US	22.635	11.562	5.414

Holland Numeraire

Wholesale Prices

	r=0	r≤1	r≤2
US	42.443	22.264	3.807

Retail Prices

	r=0	r≤1	r≤2
US	50.572	22.184	4.631

∓ 1921.8-1925.5

Key: BL=Belgium, BR=Britain, FR=France, GR=Germany, HL=Holland and US=United States. The number of lags in the vector autoregression to ensure white noise residuals was set equal to 3 in all cases.

TABLE 5

Likelihood Ratio Test of Restriction 1, 1, -1 on Cointegrating Vector

$$s_t = p_t - p^*_t + \epsilon_t$$

Belgium Numeraire

	Wholesale	Retail
Germany	---	0.951
Holland	0.646	---
U.S.	0.819	0.282

Britain Numeraire

	Wholesale
France	0.270
U.S.	0.163

France Numeraire

	Wholesale	Retail
Germany	---	0.760
Holland	0.464	0.225
U.S.	0.437	0.199

German Numeraire

	Wholesale	Retail
Holland	0.458	0.518
U.S.	---	0.264

Key: The number of lags in the vector autoregression to ensure white noise residuals was set equal to 3 in all cases.

TABLE 6

Unit Root Tests of Real Exchange Rates

Phillips-Perron

Wholesale Prices

	$z(t_{\hat{\alpha}})$	$z(t_{\alpha}^{*})$	$z(\Phi_1)$	$z(t_{\tilde{\alpha}})$	$z(\Phi_2)$	$z(\Phi_3)$
Belgium[+]						
BR	1.537	-1.863	3.244	-1.232	2.657	2.143
FR	-0.649	-1.365	0.994	-0.320	1.738	2.606
HL	1.278	-1.786	2.934	-1.088	2.303	1.896
US	0.905	-1.200	1.356	-1.270	1.265	1.139
Britain						
FR	1.802	-0.207	1.863	-2.187	4.045	3.221
GR*	3.032	-2.895	7.698	1.664	7.038	5.505
HL	0.887	-2.325	3.347	2.184	2.310	2.925
US	1.073	-1.729	2.713	-1.609	2.023	1.712
France						
GR*	3.260	-2.982	8.144	1.811	7.419	5.917
HL	1.487	-0.215	1.370	-2.265	3.470	3.262
US	1.028	-0.387	0.722	-2.222	2.682	3.248
Germany*						
HL	3.117	2.907	7.754	1.679	7.003	5.579
US	2.999	2.933	7.835	1.735	6.984	5.692
Holland						
US	-1.400	-1.378	1.885	-1.485	1.601	1.339

TABLE 6 (cont'd)

Retail Prices

	$z(\hat{t}_\alpha)$	$z(t_\alpha^*)$	$z(\Phi_1)$	$z(\tilde{t}_\alpha)$	$z(\Phi_2)$	$z(\Phi_3)$
Belgium						
BR	1.811	-0.844	2.310	-1.374	2.881	1.219
FR	-0.209	-2.422	3.267	-0.188	2.584	3.763
GR*	2.464	2.567	5.732	1.680	6.406	5.611
HL	1.340	-0.705	1.479	-1.603	2.125	1.406
US	1.091	-0.805	1.105	-1.724	1.792	1.600
Britain						
FR	1.752	-0.183	1.594	-2.809	5.199	5.248
GR*	2.389	-2.557	5.655	1.615	6.164	5.161
HL	0.769	-2.464	3.709	-2.352	2.553	3.339
US	1.003	-1.493	2.179	-1.629	1.854	1.571
France						
GR*	2.486	2.537	5.656	1.682	6.418	5.504
HL	1.279	-0.046	0.927	-2.758	4.101	4.895
US	0.937	-0.256	0.549	-2.428	3.159	4.194
Germany*						
HL	2.432	2.588	5.751	1.643	6.131	5.276
US	2.344	2.596	5.781	1.706	6.155	5.449
Holland						
US	-0.982	-1.236	1.222	-1.559	1.178	1.266

TABLE 6 (cont'd)

KPSS Tests

Wholesale Prices

Belgium

	No Trend		Trend	
	k=4	k=6	k=4	k=6
BR	0.896	0.668	0.218	0.170
FR	0.257	0.206	0.222	0.180
HL	0.886	0.659	0.210	0.164
US	0.832	0.616	0.161	0.129

Britain

	No Trend		Trend	
	k=4	k=6	k=4	k=6
FR	1.110	0.825	0.135	0.116
GR*	0.717	0.558	0.202	0.171
HL	0.178	0.146	0.181	0.146
US	0.666	0.510	0.231	0.176

France

	No Trend		Trend	
	k=4	k=6	k=4	k=6
GR*	0.719	0.560	0.202	0.171
HL	1.087	0.804	0.129	0.108
US	0.992	0.736	0.155	0.125

TABLE 6 (cont'd)

Germany*

	No Trend		Trend	
	k=4	k=6	k=4	k=6
HL	0.715	0.557	0.202	0.171
US	0.712	0.555	0.202	0.171

Holland

	No Trend		Trend	
	k=4	k=6	k=4	k=6
US	0.775	0.588	0.218	0.170

Retail Prices

Belgium

	No Trend		Trend	
	k=4	k=6	k=4	k=6
BR	1.099	0.814	0.180	0.146
FR	0.677	0.525	0.249	0.205
GR*	0.722	0.576	0.164	0.153
HL	1.056	0.780	0.168	0.135
US	1.016	0.751	0.136	0.109

Britain

	No Trend		Trend	
	k=4	k=6	k=4	k=6
FR	1.114	0.831	0.101	0.097
GR*	0.733	0.575	0.168	0.155
HL	0.297	0.264	0.097	0.088
US	0.748	0.575	0.218	0.171

TABLE 6 (cont'd)

France

	No Trend		Trend	
	k=4	k=6	k=4	k=6
GR*	0.725	0.577	0.164	0.152
HL	1.066	0.794	0.118	0.104
US	0.963	0.719	0.180	0.147

Germany*

	No Trend		Trend	
	k=4	k=6	k=4	k=6
HL	0.721	0.573	0.170	0.157
US	0.718	0.572	0.169	0.155

Holland

	No Trend		Trend	
	k=4	k=6	k=4	k=6
US	0.640	0.490	0.211	0.166

\+ 1921.8 - 1925.5
* 1921.1 - 1923.8

Key: The 5% critical values for $z(\hat{t}_\alpha)$, $z(t_\alpha^*)$ and $z(\tilde{t}_\alpha)$ are -1.95, -2.86, and -3.41 respectively. The 95% significance level for $z(\Phi_1)$, $z(\Phi_2)$ and $z(\Phi_3)$ are 4.59, 4.68 and 6.25 respectively. For the KPSS tests, k is the number of lags in the residual series; the 5% critical values are 0.146 when a trend term is included in the regression and 0.463 when only a constant is included in the regression.

TABLE 7

Phillips-Perron Tests

Real Money Balances

Wholesale Prices

	Belgium	Britain	France	Germany	Holland
$z(t_{\hat{\alpha}})$	-1.263	-0.966	-1.695	1.750	-0.0573
$z(t_{\alpha^*})$	-1.537	-3.779	-3.015	-0.877	-8.211
$z(\Phi_1)$	2.084	7.922	4.250	1.823	133.671
$z(t_{\tilde{\alpha}})$	-1.229	-3.554	-3.219	-1.705	-8.680
$z(\Phi_2)$	1.663	5.738	7.823	4.308	102.827
$z(\Phi_3)$	1.449	8.154	13.384	3.105	154.876

Real Money Balances

Retail Prices

	Belgium	Britain	France	Germany	Holland
$z(t_{\hat{\alpha}})$	-1.290	-1.037	-1.527	-1.342	-0.042
$z(t_{\alpha^*})$	-2.862	-3.168	3.027	-1.232	-7.589
$z(\Phi_1)$	4.441	5.918	3.211	0.895	117.949
$z(t_{\tilde{\alpha}})$	-3.786	-2.616	-3.621	-1.716	-8.160
$z(\Phi_2)$	5.995	3.955	9.840	1.162	93.228
$z(\Phi_3)$	9.023	5.372	17.541	1.618	140.365

TABLE 7 (cont'd)

Forward Rates

U.S. Numeraire

	Belgium	Britain	France	Germany	Holland
$z(t_{\hat{\alpha}})$	0.847	-1.056	0.822	2.803	1.109
$z(t_{\alpha^*})$	-0.986	-1.490	-0.590	2.364	-1.222
$z(\Phi_1)$	1.055	1.725	0.670	5.070	1.642
$z(t_{\bar{\alpha}})$	-1.687	-1.657	-2.288	1.229	-1.698
$z(\Phi_2)$	1.633	1.148	2.889	5.094	1.720
$z(\Phi_3)$	1.772	1.557	3.874	3.928	1.503

Analysis of the Forward Premium

U.S. Numeraire

	Belgium	Britain	France	Germany	Holland
$z(t_{\hat{\alpha}})$	-7.646	-3.431	-3.002	0.695	-3.394
$z(t_{\alpha^*})$	-7.403	-3.447	-2.849	0.519	-3.193
$z(\Phi_1)$	86.835	10.308	9.654	1.082	9.362
$z(t_{\bar{\alpha}})$	-7.268	-3.449	-3.862	-1.444	-2.975
$z(\Phi_2)$	59.217	7.856	13.742	5.108	6.855
$z(\Phi_3)$	89.700	11.514	21.993	7.970	10.215

Key: The 5% critical values for $z(t_{\hat{\alpha}})$, $z(t_{\alpha}^{*})$ and $z(t_{\bar{\alpha}})$ are -1.95, -2.86, and -3.41 respectively. The 95% significance level for $z(\Phi_1)$, $z(\Phi_2)$ and $z(\Phi_3)$ are 4.59, 4.68 and 6.25 respectively.

TABLE 8

Analysis of the Monthly Forward Premium

KPSS Tests

	No Trend		Trend	
	k=4	k=6	k=4	k=6
Belgium	0.055	0.081	0.145	0.205
Britain	0.130	0.094	0.357+	0.255
France	0.085	0.074	0.698**	0.515**
Germany	0.192**	0.150**	0.650**	0.439+
Holland	0.083	0.071	0.308	0.243

Autocorrelation Function

Monthly Forward Premium

lag	Belgium	Britain	France	Germany	Holland
1	0.025	0.542	0.556	0.670	0.568
2	0.012	0.386	0.459	0.467	0.383
3	-0.058	0.447	0.434	0.444	0.343
4	-0.203	0.333	0.304	0.376	0.134
5	-0.141	0.291	0.203	0.392	0.164
6	0.009	0.168	0.130	0.394	0.102
7	0.017	0.094	0.086	0.180	0.024
8	0.025	0.037	0.107	0.134	-0.036
9	0.011	-0.046	0.041	0.123	-0.111
10	-0.003	-0.165	-0.085	0.026	-0.192
11	0.019	-0.208	0.095	-0.067	-0.197
12	0.009	-0.242	-0.011	-0.115	-0.298

Key: The 5% critical values for the KPSS tests are 0.146 when a trend term is included in the regression and 0.463 when only a constant is included in the regression; k is the number of lags in the residual series.

TABLE 9

Money Demand Estimation

$$\ln(M/P)_t = \alpha + \beta(\ln f_t - \ln s_t) + \epsilon_t$$

Wholesale Prices

	BL	BR	FR	HL
α	16.555 (0.025)	16.377 (0.011)	15.732 (0.032)	15.723 (0.062)
β	-38.591 (14.437)	7.439 (3.087)	-27.809 (7.152)	34.181 (33.606)
R^2	0.140	0.157	0.229	0.020
D.W.	0.197	0.340	0.356	2.103

Retail Prices

	BL	BR	FR	HL
α	16.665 (0.014)	16.308 (0.011)	15.908 (0.021)	15.729 (0.063)
β	-0.148 (1.881)	11.295 (2.557)	-18.934 (4.805)	30.027 (34.363)
R^2	0.001	0.277	0.233	0.015
D.W.	0.050	0.541	0.467	2.012

Key: BL = Belgium, BR = Britain, FR = France and HL = Holland. All equations are estimated using ordinary least squares. Standard errors are in parentheses. D.W. is the Durbin Watson statistic.

Table 10

Money Demand Estimation with Correction for Autocorrelation

Wholesale Prices

	BL	BR	FR
α	16.445	16.401	15.417
	(0.102)	(0.023)	(0.270)
β	1.456	1.377	0.211
	(4.495)	(1.371)	(2.891)
R^2	0.941	0.782	0.906
D.W.	1.447	2.446	2.539
$\hat{\rho}$	0.945	0.780	0.958

Retail Prices

	BL	BR	FR
α	16.568	16.338	15.787
	(0.239)	(0.031)	(0.149)
β	0.027	0.794	-0.357
	(0.313)	(1.575)	(2.733)
R^2	0.950	0.791	0.823
D.W.	0.939	2.243	2.400
$\hat{\rho}$	0.989	0.811	0.929

Key: BL = Belgium, BR = Britain, and FR = France. All equations are estimated using ordinary least squares with the Cochrane-Orcutt autocorrelation transformation. Standard errors are in parentheses. D.W. is the Durbin Watson statistic.

TABLE 11

Money Demand Estimation with Real Income

$$lm(M/P)_t = \alpha + \beta(\ln f_t - \ln s_t) + \gamma \ln(\text{income})_t + \epsilon_t$$

	Wholesale Prices		Retail Prices	
	BR	FR	BR	FR
α	17.222 (0.793)	19.070 (0.720)	16.559 (1.007)	18.303 (0.535)
β	1.642 (1.389)	-0.886 (3.120)	0.838 (1.609)	-1.325 (2.859)
γ	-0.180 (0.174)	-0.761 (0.162)	-0.048 (0.221)	-0.545 (0.120)
R^2	0.787	0.910	0.791	0.842
D.W.	2.523	2.094	2.257	2.071
$\hat{\rho}$	0.788	0.761	0.818	0.696

Key: BR = Britain and FR = France. All equations are estimated using ordinary least squares with the Cochrane-Orcutt autocorrelation transformation. Standard errors are in parentheses. D.W. is the Durbin Watson statistic.

TABLE 12

Cointegration Tests for German Real Money Balances

Wholesale Prices

r=0	r≤1
6.494	2.206

Retail Prices

r=0	r≤1
7.584	0.895

Key: The number of lags in the vector autoregression to ensure white noise residuals was set equal to 3.

LIST OF REFERENCES

Abel, A., R. Dornbusch, J. Huizinga and A. Marcus (1979), "Money Demand During Hyperinflation," Journal of Monetary Economics, 5, 97-104.

Abuat, Niso and Philippe Jorion (1990), "Purchasing Power Parity in the Long Run," Journal of Finance, 45, 157-174.

Adler, Michael and Bruce Lehmann (1983), "Deviations from Purchasing Power Parity in the Long Run," Journal of Finance, 38, 1471-1487.

Ardeni, Pier G. and Diego Lubian (1989), "Purchasing Power Parity in the 1920s," Economics Letters, 30, 357-362.

Ahking, Francis (1990), "Further Results on Long-Run Purchasing Power Parity in the 1920s," European Economic Review, 34, 913-919.

Baillie, Richard T. and David Selover (1987), "Cointegration and Models of Exchange Rate Determination," International Journal of Forecasting,3, 43-51.

Baillie, Richard T. and Rowena A. Pecchenino (1991), "The Search for Equilibrium Relationships in International Finance: the Case of the Monetary Model," Journal of International Money and Finance, 10,582-593.

Burmeister, Edwin and Kent Wall (1987), "Unobserved Rational Expectations and the German Hyperinflation with Endogenous Money Supply," International Economic Review, 28, 15-32.

Cagan, P. (1956), "The Monetary Dynamics of Hyperinflation," in Studies in the Quantity Theory of Money, Milton Friedman ed., Chicago: University of Chicago Press.

Cassel, Gustav (1916), The Present Situation in Foreign Exchanges", Economic Journal, 26, 62-65.

Cassel, Gustav (1918), "Abnormal Deviations in International Exchanges, Economic Journal, 28,413-415.

Christiano, Lawrence (1987), "Cagan's Model of Hyperinflation Under Rational Expectations," International Economic Review, 28, 33-49.

Corbae, Dean and Sam Ouliaris (1988), "Cointegration and Tests of Purchasing Power Parity," Review of Economics and Statistics, 70, 508-511.

Darby, Michael (1983), "Movements in Purchasing Power Parity: The Short and the Long Runs," in The International Transmission of Inflation, Michael Darby, James Lothian, Arthur Gandolfi, Anna Schwartz and Alan Stockman eds., Chicago: University of Chicago Press.

Desai, M. and M. Keil (1986), "The Search for a Stable Money Demand Function During the German Hyperinflation," Unpublished Manuscript, London School of Economics.

Diebold, F., Husted, S. and M. Rush (1991), "Real Exchange Rates Under the Gold Standard," Journal of Political Economy, 99, 1252-1271.

Dornbusch, R. (1976), "Expectations and Exchange Rate Dynamics," Journal of Political Economy, 84, 1161-1176.

Einzig, Paul (1937), The Theory of Forward Exchange, London: MacMillan and Company.

Enders, Walter (1988), "ARIMA and Cointegrated Tests of PPP Under Fixed and Flexible Exchange Rate Regimes," Review of Economics and Statistics, 70, 504-508.

Evans, Paul (1978), "Time-series Analysis of the German Hyperinflation," International Economic Review, 19, 195-209.

Frenkel, Jacob (1976), "A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence," Scandinavian Journal of Economics, 78, 200-224.

Frenkel, Jacob (1977), "The Forward Exchange Rate, Expectations and the Demand for Money: The German Hyperinflation," American Economic Review, 67, 653-670.

Frenkel, Jacob (1978), "Purchasing Power Parity: Doctrinal Perspective and Evidence from the 1920s," Journal of International Economics, 8, 169-191.

Frenkel, Jacob (1979), "Further Evidence on Expectation and the Demand for Money During the German Hyperinflation," Journal of Monetary Economics, 5, 81-96.

Frenkel, Jacob (1980), "Exchange Rates, Prices and Money: Lessons from the 1920s," American Economic Review, 70, 235-242.

Frenkel, Jacob (1981), "Flexible Exchange Rates, Prices and the Role of 'News': Lessons from the 1970s," Journal of Political Economy, 89, 665-705.

Frenkel, Jacob and H.G. Johnson (1978), The Economics of Exchange Rates: Selected Studies, London: Addison-Wesley.

Hakkio, Craig (1984), "A Re-examination of Purchasing Power Parity, A multi-country and Multi-period Study," Journal of International Economics, 17, 265-277.

Hakkio, Craig and Mark Rush (1991), "Cointegraion: How Short is the Long Run?," Journal of International Money and Finance, 10, 571-581.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," Journal of Economic Dynamics and Control, 2, 231-254.

Karfakis, Costas and Demetrious Moschos (1989), "Testing for Long Run Purchasing Power Parity: A Time Series Analysis for the Greek Drachma," Economics Letters, 30,245-248.

Kim, Yoonbai (1990a), "Purchasing Power Parity in the Long-Run: A Cointegraion Approach," Journal of Money, Credit and Banking, 22, 491-503.

Kim, Yoonbai (1990b), "Purchasing Power Parity: Another Look at the Long-Run Data," Economics Letters, 32, 339-344.

Kwiatkowski, Denis, Peter C.B. Phillips, Peter Schmidt, and Yongcheol Shin (1991), "Testing the Null Hypothesis of Stationarity Against the Alternative Hypothesis of a Unit Root: How Sure Are We that Time Series Contain a Unit Root?," Unpublished Manuscript, Michigan State University.

League of Nations, Monthly Bulliten of Statistics, 1921-1926.

Mark, Nelson (1990), "Real and Nominal Exchange Rates in the Long-Run: An Empirical Investigation," Journal of International Economics, 28, 115-136.

McCulloch, J.H. (1975), "Operational Aspects of the Siegal Paradox," Quarterly Journal of Economics, 89, 170-172.

McNoun, Robert and Myles Wallace (1989), National Price Levels, Purchasing Power Parity, and Cointegration: A Test for Four High Inflation Economies," Journal of International Money and Finance, 8, 533-545.

Mussa, Michael (1982), "A Model of Exchange Rate Dynamics," Journal of Political Economy, 90, 74-104.

Officer, Lawrence (1976), "The Purchasing Power Parity Theory of Exchange Rates: A Review Article," IMF Staff Papers, 23, 1-61.

Phillips, Peter C.B. (1987), "Time Series Regression with a Unit Root," Econometrica, 55, 277-301.

Phillips, Peter C.B. and Pierre Perron (1988), "Testing for a Unit Root in Time Series Regression," Biometrika, 75, 335-346.

Pippenger, John (1982), "Purchasing Power Parity: An Analysis of Predictive Errors," Canadian Journal of Economics, 15, 335-346.

Ricardo, David (1811), "The High Price of Bullion, a Proof of the Depreciation of Bank Notes," in P. Sraffa ed., The Works and Correspondences of David Ricardo, vol 3, 1966.

Ricardo, David (1821), "On the Principles of Political Economy and Taxation" in P. Sraffa ed., The Works and Correspondences of David Ricardo, vol 3, 1966.

Roll, Richard (1979), "Violations of Purchasing Power Parity and Their Implication for Efficient International Commodity Markets," in International Finance and Trade, vol. 1, Marshall Sarnat and G.P. Szego eds., Cambridge: Ballinger Publishing Company.

Rush, Mark and Steven Husted (1985), "Purchasing Power Parity in the Long-Run," Canadian Journal of Economics, 18, 137-145.

Salemi, Michael (1979), "Adaptive Expectations, Rational Expectations, and Money Demand in Hyperinflation Germany," Journal of Monetary Economics, 5, 593-604.

Salemi, Michael (1980a), "The Forward Exchange Rate, Expectations, and the Demand for Money-The German Hyperinflation: A Comment," American Economic Review, 70, 763-769.

Salemi, Michael (1980b), "Expected Exchange Rate Depreciation and the Demand for Money in Hyperinflation Germany," Journal of Money, Credit, and Banking, 12, 592-602.

Sargent, Thomas and Neil Wallace (1973), "Rational Expectations and the Dynamics of Hyperinflation," International Economic Review, 14, 328-350.

Sargent, Thomas (1977), "The Demand for Money During Hyperinflations Under Rational Expectations," International Economic Review, 18, 59-82.

Shepherd, Henry (1936), The Monetary Experience of Belgium, Princeton: Princeton University Press.

Siegal, Jeremy (1972), "Risk, Interest Rates and the Forward Exchange," Quarterly Journal of Economics, 86, 303-309.

Taylor, Mark (1988), "An Empirical Examination of Long-Run Purchasing Power Using Cointegration Techniques," Applied Economics, 20, 1369-1381.

Taylor, Mark and Patrick McMahon (1988), "Long Run Purchasing Power Parity in the 1920s," European Economic Review, 32, 179-197.

Tinbergen, J. (1934), International Abstract of Economic Statistics 1919-1930, International Conference of Economic Time Series, London.

APPENDIX 1

APPENDIX 1

Weekly Spot Exchange Rates

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
2/25/22	51.62	49.30	975	11.50	86.88	22.46	4.3975
3/4/22	51.33	48.65	1086	11.53	84.13	22.54	4.3875
3/11/22	52.07	48.83	1124	11.52	85.75	22.50	4.3600
3/18/22	51.42	48.54	1228	11.56	85.50	22.51	4.4000
3/24/22	52.12	48.50	1400	11.59	85.50	22.56	4.3850
4/1/22	52.12	48.50	1282	11.58	85.00	22.55	4.3775
4/8/22	51.97	48.10	1330	11.62	82.75	22.62	4.4000
4/15/22	51.61	47.56	1277	11.63	81.00	22.69	4.4175
4/22/22	51.50	47.40	1185	11.64	81.50	22.71	4.4200
4/29/22	52.12	48.27	1206	11.60	84.00	22.77	4.4225
5/6/22	53.04	48.49	1231	11.57	82.75	23.01	4.4500
5/13/22	53.55	48.78	1280	11.50	84.75	23.06	4.4750
5/20/22	53.55	49.07	1342	11.46	87.25	23.32	4.4475
5/27/22	52.87	48.87	1305	11.43	85.50	23.29	4.4500
6/3/22	53.16	49.09	1220	11.48	86.00	23.38	4.4750
6/10/22	53.61	49.59	1333	11.50	87.50	23.52	4.4975
6/17/22	53.87	51.03	1432	11.49	89.50	23.42	4.4500
6/24/22	54.82	52.16	1500	11.48	94.00	23.25	4.4025
7/1/22	55.52	52.64	1733	11.47	94.00	23.27	4.4200
7/8/22	58.80	56.00	2305	11.47	99.50	23.27	4.4525
7/15/22	56.82	53.82	1965	11.46	97.25	23.16	4.4425
7/22/22	56.09	53.10	2235	11.45	96.00	23.32	4.4600
7/29/22	57.25	54.17	2677	11.48	97.50	23.26	4.4475
8/5/22	57.54	54.38	3362	11.51	96.25	23.43	4.4550
8/12/22	57.57	54.46	3440	11.49	97.00	23.45	4.4625
8/19/22	59.12	56.10	5540	11.49	98.50	23.48	4.4800
8/26/22	62.32	59.40	8500	11.44	103.00	23.46	4.4725
9/2/22	60.12	57.00	5750	11.45	101.50	23.48	4.4675
9/9/22	60.90	57.56	6200	11.46	102.50	23.50	4.4550
9/16/22	61.72	58.26	6525	11.43	105.25	23.65	4.4300
9/23/22	61.55	58.09	6087	11.41	105.00	23.66	4.4150
9/30/22	61.56	57.77	7100	11.29	103.25	23.44	4.3700
10/7/22	62.27	58.10	9670	11.37	103.00	23.60	4.4175
10/14/22	62.76	58.52	12070	11.39	104.50	23.96	4.4375
10/21/22	65.22	60.33	19200	11.40	106.50	24.44	4.4675
10/28/22	68.05	62.15	17950	11.43	112.50	24.69	4.4625
11/4/22	69.97	64.97	26000	11.38	106.50	24.36	4.4675
11/11/22	74.06	69.52	35500	11.39	101.00	24.36	4.4600
11/18/22	68.12	63.75	29750	11.40	97.00	24.23	4.4800
11/25/22	67.90	62.97	31500	11.41	94.50	24.15	4.5000

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
12/2/22	69.30	64.25	36000	11.41	93.25	24.12	4.5275
12/9/22	70.52	64.70	37000	11.47	91.00	24.25	4.5700
12/16/22	67.80	61.62	28700	11.61	91.50	24.47	4.6475
12/23/22	68.42	62.65	31000	11.67	90.75	24.50	4.6500
12/30/22	69.25	63.57	33200	11.71	91.50	24.45	4.6350
1/6/23	71.95	66.20	39630	11.74	92.00	24.55	4.6500
1/13/23	73.22	66.82	48500	11.80	94.00	24.73	4.6750
1/20/23	78.00	70.70	85000	11.78	97.00	24.94	4.6675
1/27/23	81.35	72.25	125000	11.76	97.00	24.86	4.6400
2/3/23	83.10	73.02	165000	11.87	96.50	24.85	4.6725
2/10/23	85.47	73.35	142000	11.85	96.75	24.93	4.6825
2/17/23	89.23	78.45	80000	11.86	98.00	24.97	4.6900
2/24/23	88.27	77.60	105000	11.89	97.50	25.04	4.7150
3/3/23	88.40	77.45	106000	11.89	97.75	25.09	4.7025
3/10/23	90.67	78.00	97000	11.89	98.50	25.20	4.7100
3/17/23	87.40	75.02	97000	11.89	97.50	25.23	4.6925
3/24/23	83.65	72.17	97000	11.89	96.00	25.37	4.6900
3/31/23	81.75	70.40	101000	11.88	93.25	25.33	4.6750
4/7/23	82.15	71.00	97500	11.88	94.00	25.43	4.6675
4/14/23	81.02	70.05	98000	11.89	93.50	25.57	4.6575
4/21/23	81.07	70.07	120000	11.88	94.00	25.64	4.6525
4/28/23	79.17	68.22	136000	11.86	94.00	25.52	4.6350
5/5/23	80.25	69.30	160000	11.83	94.75	25.62	4.6275
5/12/23	80.97	69.95	194000	11.81	95.00	25.71	4.6175
5/19/23	80.61	69.42	225000	11.81	95.00	25.65	4.6250
5/26/23	81.45	69.87	251000	11.82	96.25	25.66	4.6250
6/2/23	82.75	71.25	353000	11.81	98.75	25.62	4.6325
6/9/23	83.40	71.85	390000	11.76	99.00	25.66	4.6125
6/16/23	84.97	73.15	522000	11.76	100.00	25.67	4.6125
6/23/23	87.25	74.42	485000	11.77	102.25	25.73	4.6150
6/30/23	88.87	75.62	850000	11.68	104.00	25.89	4.5725
7/7/23	96.52	79.12	960000	11.65	108.50	26.68	4.5650
7/14/23	94.27	78.32	1075000	11.73	107.75	26.54	4.6050
7/21/23	93.07	77.85	1600000	11.71	106.00	25.95	4.5950
7/28/23	94.95	77.90	4500000	11.63	105.00	25.66	4.5850
8/4/23	98.95	78.90	5200000	11.62	105.50	25.54	4.5700
8/11/23	102.87	80.75	15000000	11.60	107.50	25.15	4.5700
8/18/23	103.62	82.65	18000000	11.58	106.25	25.20	4.5575
8/25/23	100.07	80.35	21000000	11.58	105.25	25.20	4.5550
9/1/23	98.35	80.82	45000000	11.55	107.75	25.19	4.5450
9/8/23	99.35	81.40		11.53	105.00	25.19	4.5350
9/15/23	93.25	77.37		11.55	102.00	25.53	4.5425
9/22/23	89.40	76.02		11.56	100.75	25.55	4.5450
9/29/23	87.25	74.17		11.57	99.25	25.45	4.5525
10/6/23	90.95	77.02		11.58	101.25	25.48	4.5525
10/13/22	87.50	74.60		11.55	99.50	25.25	4.5375

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
10/20/23	87.70	75.85		11.55	100.25	25.27	4.5150
10/27/23	88.05	75.92		11.56	99.50	25.24	4.5000
11/3/23	90.60	77.67		11.52	100.50	25.09	4.4550
11/10/23	90.55	78.30		11.55	100.50	24.95	4.3900
11/17/23	96.00	81.85		11.62	102.50	24.88	4.3000
11/24/23	93.92	80.87		11.46	101.00	24.97	4.3650
12/1/23	93.50	80.42		11.45	100.25	24.87	4.3400
12/8/23	94.80	81.77		11.47	100.50	25.00	4.3600
12/15/23	94.97	82.15		11.45	100.50	25.08	4.3544
12/22/23	96.82	86.00		11.47	100.75	24.90	4.3425
12/29/23	96.77	84.82		11.39	100.00	24.77	4.3375
1/5/24	99.87	88.30		11.37	99.88	24.65	4.2900
1/12/24	100.67	90.47		11.37	97.00	24.59	4.2650
1/19/24	101.95	92.87		11.39	97.19	24.50	4.2350
1/26/24	104.25	94.25		11.40	97.38	24.50	4.2275
2/2/24	104.25	92.17		11.53	98.88	24.88	4.3450
2/9/24	107.20	94.80		11.50	98.25	24.71	4.3000
2/16/24	113.97	97.65		11.48	98.81	24.68	4.2875
2/23/24	113.75	99.75		11.53	99.25	24.90	4.3125
3/1/24	118.75	103.4		11.53	99.88	24.81	4.2975
3/8/24	131.37	117.0		11.54	101.00	24.80	4.2775
3/15/24	109.75	89.81		11.55	99.83	24.77	4.2825
3/22/24	102.50	81.25		11.63	99.69	24.86	4.2975
3/29/24	100.00	78.45		11.64	99.00	24.77	4.3000
4/5/24	89.62	74.97		11.61	99.31	24.78	4.3125
4/12/24	85.12	72.40		11.63	97.50	24.70	4.3350
4/19/24	81.25	69.57		11.70	98.25	24.75	4.3600
4/26/24	80.62	68.75		11.77	97.56	24.67	4.3825
5/3/24	81.69	67.87		11.71	97.81	24.62	4.3875
5/10/24	89.00	73.00		11.68	97.75	24.59	4.3700
5/17/24	89.75	75.82		11.67	97.75	24.62	4.3675
5/24/24	93.63	80.42		11.62	98.38	24.59	4.3450
5/31/24	97.25	84.40		11.52	99.00	24.46	4.3050
6/7/24	95.50	84.85		11.52	99.13	24.48	4.3125
6/17/24	94.13	80.82		11.55	99.25	24.45	4.3175
6/21/24	92.62	79.84		11.58	100.44	24.32	4.3325
6/28/24	93.56	81.80		11.50	100.13	24.33	4.3200
7/5/24	97.44	86.02		11.47	101.31	24.27	4.3275
7/12/24	96.12	85.07		11.56	102.00	23.98	4.3675
7/19/24	95.87	85.57		11.53	101.50	23.99	4.3775
7/26/24	95.75	86.12		11.51	101.44	23.89	4.4000
8/2/24	94.62	85.25		11.53	101.57	23.74	4.4200
8/9/24	90.25	82.15		11.61	100.63	23.85	4.5175
8/16/24	86.50	79.40		11.62	100.63	24.08	4.5500
8/23/24	90.75	83.45		11.59	101.63	23.97	4.4900
8/30/24	89.06	82.12		11.62	101.20	23.88	4.5025

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
9/6/24	89.75	84.75		11.60	102.00	23.61	4.4375
9/13/24	89.40	83.17		11.63	101.62	23.69	4.4600
9/20/24	90.05	84.05		11.60	101.77	23.63	4.4650
9/27/24	91.85	84.80		11.57	101.80	23.47	4.4725
10/4/24	92.50	84.75		11.52	101.82	23.33	4.4625
10/11/24	93.97	86.57		11.47	102.90	23.39	4.4900
11/18/24	93.37	85.82		11.49	102.85	23.38	4.4900
10/25/24	93.70	86.20		11.44	103.80	23.36	4.4900
11/1/24	93.87	86.00		11.48	103.95	23.54	4.5325
11/8/24	95.47	87.55		11.49	106.57	23.79	4.5850
11/15/24	95.80	87.65		11.54	106.95	24.02	4.6325
11/22/24	95.35	87.35		11.52	106.72	24.01	4.6350
11/29/24	94.42	85.82		11.46	106.47	23.95	4.6225
12/6/24	94.72	86.70		11.56	107.85	24.17	4.6800
12/13/24	95.00	87.57		11.63	108.80	24.22	4.6925
12/20/24	94.62	87.30		11.65	110.07	24.29	4.7075
12/27/24	94.62	87.27		11.65	109.87	24.24	4.7125
1/3/25	94.87	87.47		11.71	112.15	24.34	4.7475
1/10/25	95.92	89.12		11.79	114.00	24.72	4.7850
1/17/25	95.25	88.40		11.83	117.12	24.78	4.7738
1/24/25	93.97	88.85		11.89	116.31	24.85	4.8000
1/31/25	92.32	88.40		11.90	114.82	24.84	4.795
2/7/25	93.00	88.67		11.87	115.19	24.75	4.7750
2/14/25	95.32	91.85		11.87	116.12	24.77	4.7750
2/21/25	94.85	90.87		11.88	116.25	24.77	4.7650
2/28/25	94.95	92.57		11.90	117.50	24.77	4.7600
3/7/25	94.15	91.65		11.93	116.75	24.76	4.7675
3/14/25	94.62	92.75		11.97	117.62	24.80	4.7875
3/21/25	94.35	92.10		11.98	117.56	24.79	4.7800
3/28/25	93.15	90.60		11.98	116.75	24.78	4.7775
4/4/25	94.20	92.32		11.99	116.37	24.78	4.7825

Key: The spot exchange rates come from Einzig (1937) and represent end of the week quotations from the London exchange market. All rates are quoted vis a vis the pound.

30-Day Forward Rates

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
2/25/22	51.67	49.31	977	11.50	87.19	22.465	4.3969
3/4/22	51.38	48.66	1087	11.52	84.45	22.545	4.3863
3/11/22	52.14	48.84	1125	11.51	85.92	22.505	4.3594

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
3/18/22	51.50	48.55	1229	11.55	85.68	22.515	4.4000
3/24/22	52.19	48.50	1401	11.58	85.75	22.575	4.3850
4/1/22	52.19	48.51	1283	11.56	85.17	22.575	4.3772
4/8/22	52.05	48.11	1330	11.60	82.90	22.645	4.3994
4/15/22	51.69	47.57	1277	11.61	81.14	22.715	4.4169
4/22/22	51.57	47.39	1185	11.62	81.65	22.730	4.4200
4/29/22	52.19	48.26	1207	11.58	84.08	22.790	4.4222
5/6/22	53.11	48.48	1232	11.55	82.83	23.030	4.4497
5/13/22	53.61	48.77	1281	11.48	84.81	23.080	4.4469
5/20/22	53.61	49.06	1343	11.45	87.31	23.335	4.4463
5/27/22	52.90	48.86	1305	11.41	85.51	23.300	4.4488
6/3/22	53.19	49.08	1220	11.46	86.02	23.395	4.4738
6/10/22	53.64	49.59	1334	11.48	87.51	23.535	4.4963
6/17/22	53.90	51.03	1433	11.47	89.51	23.435	4.4488
6/24/22	54.85	52.14	1500	11.47	93.99	23.255	4.4016
7/1/22	55.55	52.59	1731	11.46	94.00	23.270	4.4194
7/8/22	58.83	55.95	2302	11.46	99.48	23.285	4.4513
7/15/22	56.86	53.77	1958	11.45	97.24	23.175	4.4419
7/22/22	56.11	53.05	2227	11.43	95.98	23.340	4.4582
7/29/22	57.27	54.09	2667	11.46	97.25	23.275	4.4444
8/5/22	57.53	54.28	3347	11.49	96.25	23.445	4.4525
8/12/22	57.58	54.39	3410	11.47	97.00	23.430	4.4600
8/19/22	59.13	56.02	5480	11.47	98.50	23.500	4.4775
8/26/22	62.33	59.29	8350	11.42	103.00	23.480	4.4700
9/2/22	60.18	56.89	5600	11.43	101.60	23.500	4.4644
9/9/22	60.95	57.52	6000	11.45	102.58	23.520	4.4525
9/16/22	61.79	58.22	6325	11.42	105.35	23.675	4.4275
9/23/22	61.62	58.05	5787	11.40	105.12	23.680	4.4113
9/30/22	61.63	57.74	6800	11.28	103.33	23.460	4.3663
10/7/22	62.33	58.07	9170	11.35	103.08	23.620	4.4138
10/14/22	62.82	58.46	11270	11.37	104.31	23.970	4.4338
10/21/22	65.26	60.27	17700	11.39	106.60	24.450	4.4625
10/28/22	68.07	62.05	15950	11.42	112.62	24.690	4.4563
11/4/22	69.99	64.85	22000	11.37	106.62	24.370	4.4625
11/11/22	74.60	69.22	28500	11.38	101.08	24.375	4.4519
11/18/22	68.13	63.58	27750	11.39	97.18	24.240	4.4700
11/25/22	67.91	62.87	27500	11.40	94.70	24.160	4.4900
12/2/22	69.31	64.15	32000	11.40	93.70	24.130	4.5175
12/9/22	70.55	64.58	32000	11.46	91.15	24.255	4.5600
12/16/22	67.90	61.54	27200	11.60	91.75	24.470	4.6375
12/23/22	68.46	62.57	29500	11.66	91.07	24.510	4.6375
12/30/22	69.30	63.54	31200	11.70	91.72	24.455	4.6238
1/6/23	71.99	66.11	36630	11.73	92.11	24.545	4.6400
1/13/23	73.26	66.77	46500	11.79	94.20	24.730	4.6650
1/20/23	78.04	70.64	77000	11.77	97.25	24.950	4.6575
1/27/23	81.38	72.18	108000	11.75	97.25	24.863	4.6300

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
3/18/22	51.50	48.55	1229	11.55	85.68	22.515	4.4000
3/24/22	52.19	48.50	1401	11.58	85.75	22.575	4.3850
4/1/22	52.19	48.51	1283	11.56	85.17	22.575	4.3772
4/8/22	52.05	48.11	1330	11.60	82.90	22.645	4.3994
4/15/22	51.69	47.57	1277	11.61	81.14	22.715	4.4169
4/22/22	51.57	47.39	1185	11.62	81.65	22.730	4.4200
4/29/22	52.19	48.26	1207	11.58	84.08	22.790	4.4222
5/6/22	53.11	48.48	1232	11.55	82.83	23.030	4.4497
5/13/22	53.61	48.77	1281	11.48	84.81	23.080	4.4469
5/20/22	53.61	49.06	1343	11.45	87.31	23.335	4.4463
5/27/22	52.90	48.86	1305	11.41	85.51	23.300	4.4488
6/3/22	53.19	49.08	1220	11.46	86.02	23.395	4.4738
6/10/22	53.64	49.59	1334	11.48	87.51	23.535	4.4963
6/17/22	53.90	51.03	1433	11.47	89.51	23.435	4.4488
6/24/22	54.85	52.14	1500	11.47	93.99	23.255	4.4016
7/1/22	55.55	52.59	1731	11.46	94.00	23.270	4.4194
7/8/22	58.83	55.95	2302	11.46	99.48	23.285	4.4513
7/15/22	56.86	53.77	1958	11.45	97.24	23.175	4.4419
7/22/22	56.11	53.05	2227	11.43	95.98	23.340	4.4582
7/29/22	57.27	54.09	2667	11.46	97.25	23.275	4.4444
8/5/22	57.53	54.28	3347	11.49	96.25	23.445	4.4525
8/12/22	57.58	54.39	3410	11.47	97.00	23.430	4.4600
8/19/22	59.13	56.02	5480	11.47	98.50	23.500	4.4775
8/26/22	62.33	59.29	8350	11.42	103.00	23.480	4.4700
9/2/22	60.18	56.89	5600	11.43	101.60	23.500	4.4644
9/9/22	60.95	57.52	6000	11.45	102.58	23.520	4.4525
9/16/22	61.79	58.22	6325	11.42	105.35	23.675	4.4275
9/23/22	61.62	58.05	5787	11.40	105.12	23.680	4.4113
9/30/22	61.63	57.74	6800	11.28	103.33	23.460	4.3663
10/7/22	62.33	58.07	9170	11.35	103.08	23.620	4.4138
10/14/22	62.82	58.46	11270	11.37	104.31	23.970	4.4338
10/21/22	65.26	60.27	17700	11.39	106.60	24.450	4.4625
10/28/22	68.07	62.05	15950	11.42	112.62	24.690	4.4563
11/4/22	69.99	64.85	22000	11.37	106.62	24.370	4.4625
11/11/22	74.60	69.22	28500	11.38	101.08	24.375	4.4519
11/18/22	68.13	63.58	27750	11.39	97.18	24.240	4.4700
11/25/22	67.91	62.87	27500	11.40	94.70	24.160	4.4900
12/2/22	69.31	64.15	32000	11.40	93.70	24.130	4.5175
12/9/22	70.55	64.58	32000	11.46	91.15	24.255	4.5600
12/16/22	67.90	61.54	27200	11.60	91.75	24.470	4.6375
12/23/22	68.46	62.57	29500	11.66	91.07	24.510	4.6375
12/30/22	69.30	63.54	31200	11.70	91.72	24.455	4.6238
1/6/23	71.99	66.11	36630	11.73	92.11	24.545	4.6400
1/13/23	73.26	66.77	46500	11.79	94.20	24.730	4.6650
1/20/23	78.04	70.64	77000	11.77	97.25	24.950	4.6575
1/27/23	81.38	72.18	108000	11.75	97.25	24.863	4.6300

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
2/3/23	83.11	72.87	135000	11.86	96.80	24.880	4.6625
2/10/23	85.47	73.23	117000	11.84	97.00	24.940	4.6725
2/17/23	89.26	78.33	60000	11.85	98.30	25.000	4.6800
2/24/23	88.30	77.50	69000	11.88	97.75	25.070	4.7050
3/3/23	88.43	77.34	89000	11.88	97.96	25.125	4.6913
3/10/23	90.71	77.91	92000	11.89	98.70	25.220	4.7000
3/17/23	87.43	74.94	94000	11.89	97.73	25.260	4.6825
3/24/23	83.68	72.09	94000	11.89	96.17	25.405	4.6800
3/31/23	81.78	70.31	96000	11.88	93.44	25.370	4.6650
4/7/23	82.17	70.95	91500	11.88	94.19	25.470	4.6600
4/14/23	81.05	70.01	93000	11.89	93.70	25.600	4.6488
4/21/23	81.10	70.03	111000	11.88	94.02	25.690	4.6438
4/28/23	79.19	68.19	121000	11.85	94.21	25.563	4.6263
5/5/23	80.28	69.26	143000	11.82	94.91	25.660	4.6182
5/12/23	81.00	69.91	172000	11.80	95.13	25.750	4.6088
5/19/23	80.63	69.39	199000	11.80	95.16	25.675	4.6163
5/26/23	81.47	69.84	215000	11.81	96.40	25.685	4.6163
6/2/23	82.77	71.21	308000	11.80	98.92	25.635	4.6238
6/9/23	83.40	71.80	365000	11.75	99.17	25.675	4.6038
6/16/23	84.97	73.10	489000	11.75	100.18	25.680	4.6063
6/23/23	87.27	74.37	420000	11.76	102.46	25.750	4.6088
6/30/23	88.89	75.56	680000	11.66	104.21	25.915	4.5663
7/7/23	96.55	79.07	585000	11.63	108.75	26.685	4.5613
7/14/23	94.31	78.30	725000	11.72	108.04	26.520	4.6006
7/21/23	93.13	77.82	900000	11.70	106.32	25.945	4.5900
7/28/23	95.00	77.86	2.9e+06	11.62	105.30	25.660	4.5813
8/4/23	98.99	78.84	200000	11.61	105.79	25.510	4.5681
8/11/23	102.82	80.71	9.0e+06	11.60	107.74	25.090	4.5688
8/18/23	103.54	82.60	9.0e+06	11.58	106.49	25.120	4.5550
8/25/23	100.01	80.31	1.4e+10	11.58	105.51	25.140	4.5528
9/1/23	98.25	80.77	2.5e+10	11.55	107.97	25.140	4.5425
9/8/23	99.26	80.37		11.53	105.22	25.135	4.5306
9/15/23	93.15	77.32		11.55	102.18	25.515	4.5388
9/22/23	89.36	76.00		11.56	100.94	25.535	4.5406
9/29/23	87.21	74.14		11.58	94.44	25.400	4.5488
10/6/23	90.88	76.94		11.58	101.41	25.450	4.5488
10/13/22	87.45	74.57		11.55	99.15	25.210	4.5331
10/20/23	87.65	75.82		11.55	100.16	25.235	4.5106
10/27/23	88.00	75.88		11.56	99.68	25.205	4.4956
11/3/23	90.54	77.60		11.52	100.60	25.060	4.4506
11/10/23	90.49	78.21		11.55	100.06	24.920	4.3825
11/17/23	95.94	81.74		11.62	102.59	24.845	4.2931
11/24/23	93.85	80.77		11.45	101.09	24.930	4.3581
12/1/23	93.42	80.36		11.43	100.18	24.840	4.3375
12/8/23	94.74	81.71		11.44	100.56	24.975	4.3550
12/15/23	97.93	82.10		11.42	100.56	25.055	4.3481

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
12/22/23	96.80	85.96		11.43	100.79	24.870	4.3363
12/29/23	96.75	84.78		11.34	100.14	24.725	4.3325
1/5/24	99.83	88.22		11.35	100.58	24.605	4.2831
1/12/24	100.64	90.25		11.34	97.06	24.565	4.2581
1/19/24	101.95	92.44		11.36	97.99	24.485	4.2281
1/26/24	104.27	93.98		11.37	97.49	24.490	4.2213
2/2/24	104.29	91.95		11.51	98.99	24.870	4.3375
2/9/24	107.22	94.55		11.48	98.34	24.700	4.2950
2/16/24	114.02	97.22		11.46	98.92	24.670	4.2844
2/23/24	113.55	99.17		11.52	99.34	24.875	4.3088
3/1/24	118.50	102.30		11.52	99.95	24.770	4.2956
3/8/24	130.47	113.45		11.54	101.08	24.760	4.2763
3/15/24	109.20	86.06		11.54	99.81	24.730	4.2819
3/22/24	102.00	80.00		11.63	99.75	24.820	4.2975
3/29/24	99.85	77.33		11.64	99.07	24.740	4.2994
4/5/24	89.57	74.52		11.60	98.37	24.740	4.3106
4/12/24	85.07	71.90		11.62	97.54	24.660	4.3325
4/19/24	81.23	69.37		11.69	98.24	24.715	4.3575
4/26/24	80.60	68.55		11.76	97.59	24.640	4.3806
5/3/24	81.69	67.62		11.69	97.81	24.595	4.3856
5/10/24	88.65	71.60		11.67	97.88	24.570	4.3681
5/17/24	89.65	75.22		11.66	97.88	24.600	4.3650
5/24/24	93.53	79.87		11.62	98.38	24.575	4.3434
5/31/24	97.10	83.70		11.51	99.00	24.450	4.3038
6/7/24	95.38	84.33		11.51	99.11	24.460	4.3113
6/17/24	94.06	80.57		11.54	99.25	24.430	4.3175
6/21/24	92.55	79.54		11.57	100.44	24.300	4.3325
6/28/24	93.49	81.50		11.49	100.17	24.300	4.3206
7/5/24	97.37	85.72		11.46	101.31	24.240	4.3284
7/12/24	96.02	84.87		11.56	102.07	23.950	4.3700
7/19/24	95.86	85.42		11.53	101.58	23.940	4.3819
7/26/24	95.73	86.05		11.52	101.54	23.840	4.4063
8/2/24	94.59	85.20		11.54	101.64	23.630	4.4238
8/9/24	90.25	82.07		11.64	100.75	23.730	4.5225
8/16/24	86.48	79.37		11.64	100.80	23.980	4.5550
8/23/24	90.72	83.39		11.60	101.83	23.850	4.4956
8/30/24	89.02	82.05		11.63	101.32	23.770	4.5081
9/6/24	89.72	84.71		11.60	102.09	23.560	4.4431
9/13/24	89.39	83.12		11.63	101.74	23.620	4.4644
9/20/24	90.05	84.00		11.59	101.99	23.580	4.4706
9/27/24	91.82	84.71		11.56	101.91	23.400	4.4781
10/4/24	92.43	84.67		11.49	101.91	23.260	4.4669
10/11/24	93.92	86.43		11.45	102.99	23.340	4.4938
11/18/24	93.31	85.67		11.47	102.94	23.330	4.4919
10/25/24	93.66	86.07		11.42	103.86	23.320	4.4931
11/1/24	93.80	85.84		11.45	103.95	23.520	4.5350

	Belgium	France	Germany	Holland	Italy	Swit	U.S.
11/8/24	95.37	87.25		11.46	106.57	23.760	4.5844
11/15/24	95.68	87.37		11.50	106.95	24.010	4.6325
11/22/24	95.23	87.15		11.47	106.72	23.940	4.6350
11/29/24	94.34	85.57		11.42	106.47	23.940	4.6228
12/6/24	94.64	86.20		11.54	107.85	24.150	4.6797
12/13/24	94.93	87.19		11.62	108.87	24.200	4.6922
12/20/24	94.59	86.88		11.64	110.12	24.270	4.7072
12/27/24	94.58	86.80		11.63	109.92	24.200	4.7122
1/3/25	94.83	86.97		11.69	112.20	24.310	4.7456
1/10/25	95.92	88.69		11.79	114.05	24.720	4.7847
1/17/25	95.25	88.16		11.83	117.17	24.780	4.7734
1/24/25	93.97	88.65		11.89	116.36	24.850	4.7997
1/31/25	92.30	88.12		11.90	114.87	24.840	4.7944
2/7/25	92.92	88.32		11.87	115.24	24.760	4.7741
2/14/25	95.23	91.40		11.87	116.18	24.775	4.7741
2/21/25	94.78	90.44		11.90	116.32	24.770	4.7644
2/28/25	94.87	92.09		11.92	117.60	24.780	4.7594
3/7/25	94.14	91.33		11.95	116.83	24.770	4.7675
3/14/25	94.63	92.50		11.99	117.68	24.810	4.7875
3/21/25	94.35	91.88		12.00	117.64	24.790	4.7800
3/28/25	93.18	90.30		12.00	116.83	24.790	4.7781
4/4/25	94.23	91.75		12.00	116.54	24.790	4.7828

Key: The 30-Day forward rates come from Einzig (1937) and represent end of the week quotations from the London exchange market. All rates are quoted vis a vis the pound.

90-Day Forward Rates

	Belgium	France	Holland	Italy	Swit	U.S.
2/25/22	51.77	49.32	11.493	87.81	22.48	4.39563
3/4/22	51.48	48.67	11.493	85.09	22.56	4.38375
3/11/22	52.28	48.85	11.490	86.26	22.52	4.35813
3/18/22	51.65	48.56	11.530	86.04	22.53	4.40000
3/24/22	52.33	48.50	11.545	86.25	22.61	4.38469
4/1/22	52.33	48.52	11.520	85.51	22.63	4.37656
4/8/22	52.21	48.12	11.560	83.20	22.70	4.39813
4/15/22	51.84	47.58	11.555	81.41	22.77	4.41563
4/22/22	51.70	47.37	11.580	81.94	22.77	4.41906
4/29/22	52.33	48.25	11.540	84.24	22.83	4.42156
5/6/22	53.25	48.46	11.510	82.99	23.07	4.44906
5/13/22	53.79	48.75	11.440	84.92	23.12	4.44563
5/20/22	53.79	49.04	11.415	87.42	23.37	4.44375
5/27/22	52.96	48.84	11.363	85.53	23.32	4.44625

	Belgium	France	Holland	Italy	Swit	U.S.
6/3/22	53.24	49.05	11.405	86.06	23.43	4.47125
6/10/22	53.69	49.58	11.425	87.53	23.57	4.49375
6/17/22	53.95	51.02	11.415	89.53	23.47	4.44625
6/24/22	54.90	52.10	11.443	93.97	23.27	4.39969
7/1/22	55.61	52.49	11.433	94.00	23.32	4.41813
7/8/22	58.89	55.85	11.425	99.44	23.32	4.44875
7/15/22	56.93	53.67	11.430	97.21	23.21	4.44063
7/22/22	56.15	52.94	11.390	95.94	23.38	4.45438
7/29/22	57.30	53.93	11.420	97.25	23.31	4.43813
8/5/22	57.51	54.11	11.450	96.25	23.48	4.44750
8/12/22	57.60	54.25	11.430	97.00	23.39	4.45500
8/19/22	59.15	55.86	11.430	98.50	23.54	4.47250
8/26/22	62.35	59.16	11.380	103.00	23.52	4.46500
9/2/22	60.22	56.76	11.390	101.80	23.54	4.45625
9/9/22	61.05	57.47	11.430	102.74	23.56	4.44750
9/16/22	61.93	58.17	11.400	105.55	23.73	4.42250
9/23/22	61.76	58.00	11.380	105.36	23.72	4.40375
9/30/22	61.77	57.68	11.260	103.49	23.50	4.35875
10/7/22	62.45	58.01	11.310	103.24	23.66	4.40625
10/14/22	62.94	58.34	11.330	104.43	23.79	4.42625
10/21/22	65.34	60.15	11.370	106.80	24.47	4.45250
10/28/22	68.11	61.85	11.400	112.86	24.72	4.43750
11/4/22	70.03	64.61	11.350	106.86	24.39	4.44250
11/11/22	74.64	68.82	11.360	101.24	24.41	4.43188
11/18/22	68.15	63.35	11.370	97.54	24.26	4.45000
11/25/22	67.93	62.67	11.380	95.10	24.18	4.47000
12/2/22	69.33	63.95	11.380	93.85	24.15	4.49750
12/9/22	70.61	64.40	11.440	91.45	24.27	4.54000
12/16/22	68.10	61.40	11.580	92.25	24.49	4.61750
12/23/22	68.54	62.50	11.640	91.65	24.53	4.61750
12/30/22	69.40	63.49	11.680	92.16	24.47	4.60500
1/6/23	72.08	66.00	11.710	92.33	24.54	4.62125
1/13/23	73.34	66.67	11.770	94.60	24.73	4.64500
1/20/23	78.16	70.54	11.750	97.40	24.97	4.63750
1/27/23	81.49	72.09	11.738	97.75	24.87	4.61625
2/3/23	83.13	72.72	11.840	97.40	24.94	4.64250
2/10/23	85.54	73.05	11.820	97.50	24.96	4.65250
2/17/23	89.33	78.20	11.830	98.80	25.06	4.66000
2/24/23	88.36	77.35	11.865	98.00	25.12	4.68500
3/3/23	88.41	77.22	11.890	98.32	25.19	4.66875
3/10/23	90.79	77.79	11.890	99.03	25.26	4.67750
3/17/23	87.45	74.82	11.890	98.18	25.31	4.66250
3/24/23	83.77	71.98	11.890	96.45	25.38	4.66000
3/31/23	81.85	70.21	11.880	93.70	25.44	4.64500
4/7/23	82.25	70.88	11.880	94.45	25.54	4.64250
4/14/23	81.11	69.95	11.890	93.95	25.67	4.63000

	Belgium	France	Holland	Italy	Swit	U.S.
4/21/23	81.17	69.96	11.880	94.55	25.76	4.62625
4/28/23	79.25	68.13	11.840	94.55	25.66	4.60750
5/5/23	80.34	69.20	11.813	95.05	25.73	4.60000
5/12/23	81.06	69.85	11.780	95.32	25.81	4.58875
5/19/23	80.68	69.34	11.780	95.40	25.72	4.59750
5/26/23	81.50	69.79	11.790	96.66	25.72	4.60000
6/2/23	82.81	71.14	11.780	99.23	25.65	4.60813
6/9/23	83.42	71.71	11.730	99.45	25.70	4.58625
6/16/23	84.99	73.00	11.733	100.46	25.70	4.59250
6/23/23	87.29	74.30	11.738	102.80	25.78	4.59625
6/30/23	88.91	75.49	11.640	104.58	25.95	4.55500
7/7/23	96.58	79.00	11.605	109.15	26.71	4.55125
7/14/23	94.40	78.25	11.700	108.45	26.49	4.59125
7/21/23	93.20	77.80	11.685	106.83	25.94	4.58125
7/28/23	95.11	77.82	11.603	105.77	25.64	4.57375
8/4/23	99.07	78.80	11.603	106.25	25.46	4.56313
8/11/23	102.78	80.64	11.590	108.13	25.02	4.56375
8/18/23	103.48	82.55	11.571	106.90	25.03	4.55125
8/25/23	99.93	80.25	11.575	105.97	25.08	4.54625
9/1/23	98.17	80.71	11.546	108.35	25.04	4.53750
9/8/23	99.19	81.33	11.526	105.55	25.04	4.52188
9/15/23	93.06	77.27	11.546	102.55	25.43	4.52750
9/22/23	89.31	75.95	11.555	101.20	25.48	4.53000
9/29/23	87.17	74.12	11.563	99.75	25.37	4.54000
10/6/23	90.82	76.89	11.573	101.73	25.40	4.54000
10/13/22	87.38	74.52	11.545	99.93	25.14	4.52313
10/20/23	87.58	75.78	11.549	100.75	25.17	4.50063
10/27/23	87.95	75.83	11.562	99.95	25.14	4.48625
11/3/23	90.48	77.50	11.521	100.80	25.00	4.44000
11/10/23	90.43	78.10	11.552	100.88	24.86	4.36750
11/17/23	95.86	81.63	11.598	102.84	24.78	4.27938
11/24/23	93.76	80.57	11.430	101.32	24.86	4.34375
12/1/23	93.28	80.25	11.400	101.34	24.78	4.32563
12/8/23	94.62	81.61	11.425	100.75	25.93	4.34625
12/15/23	94.87	82.02	11.380	100.78	25.01	4.33938
12/22/23	96.74	85.89	11.385	100.97	24.85	4.32625
12/29/23	96.69	84.74	11.290	100.28	24.68	4.32250
1/5/24	99.79	88.11	11.320	100.08	24.56	4.27250
1/12/24	100.59	90.04	11.310	97.17	24.52	4.24750
1/19/24	101.95	91.67	11.310	98.25	24.46	4.21563
1/26/24	104.30	93.48	11.330	97.70	24.46	4.21063
2/2/24	104.39	91.57	11.470	99.16	24.84	4.32625
2/9/24	107.27	94.15	11.450	98.48	24.67	4.28500
2/16/24	114.12	96.40	11.435	99.14	24.64	4.27625
2/23/24	113.25	97.95	11.490	99.50	24.84	4.30188
3/1/24	118.00	99.20	11.500	100.08	24.71	4.29188

	Belgium	France	Holland	Italy	Swit	U.S.
3/8/24	128.17	107.00	11.525	101.20	24.68	4.27250
3/15/24	108.15	80.56	11.525	99.81	24.67	4.27875
3/22/24	101.60	78.00	11.615	99.81	24.76	4.29563
3/29/24	99.65	75.45	11.628	99.17	24.68	4.29813
4/5/24	89.42	73.17	11.580	98.48	24.68	4.30500
4/12/24	84.92	70.80	11.610	97.67	24.60	4.32688
4/19/24	81.21	69.02	11.678	98.24	24.65	4.35188
4/26/24	80.60	68.15	11.735	97.65	24.59	4.37375
5/3/24	81.64	67.25	11.665	97.86	24.55	4.37813
5/10/24	88.20	69.65	11.648	97.88	24.53	4.36125
5/17/24	89.48	74.57	11.643	97.76	24.57	4.35938
5/24/24	93.33	78.92	11.600	98.38	24.55	4.33938
5/31/24	96.90	82.40	11.500	98.96	24.41	4.30000
6/7/24	95.18	83.80	11.498	99.05	24.43	4.30875
6/17/24	93.88	79.97	11.523	99.17	24.40	4.31625
6/21/24	92.37	79.14	11.553	100.36	24.27	4.33125
6/28/24	93.36	80.93	11.475	100.25	24.26	4.32125
7/5/24	97.24	85.27	11.440	101.33	24.20	4.32813
7/12/24	95.90	84.49	11.555	102.15	23.91	4.37000
7/19/24	95.83	85.09	11.528	101.67	23.84	4.38375
7/26/24	95.70	85.82	11.514	101.64	23.77	4.41250
8/2/24	94.54	85.05	11.538	101.74	23.52	4.42875
8/9/24	90.25	81.93	11.633	100.88	23.63	4.52625
8/16/24	86.44	79.19	11.645	100.98	23.88	4.55813
8/23/24	90.67	83.19	11.605	102.03	23.75	4.49875
8/30/24	88.93	81.87	11.630	101.54	23.68	4.51125
9/6/24	89.64	84.60	11.600	102.30	23.41	4.44625
9/13/24	89.35	83.02	11.620	101.95	23.52	4.46688
9/20/24	90.05	83.90	11.575	102.09	23.52	4.47375
9/27/24	91.77	84.60	11.533	102.12	23.30	4.48375
10/4/24	92.34	84.56	11.455	102.12	23.15	4.47250
10/11/24	93.84	86.19	11.410	103.17	23.26	4.49875
11/18/24	93.24	85.43	11.428	103.13	23.26	4.49563
10/25/24	93.62	85.81	11.378	104.08	23.25	4.49688
11/1/24	93.75	85.52	11.410	103.95	23.46	4.53813
11/8/24	95.22	86.78	11.420	106.59	23.71	4.58438
11/15/24	95.48	86.88	11.458	106.97	23.97	4.63250
11/22/24	95.15	86.78	11.430	106.78	23.96	4.63500
11/29/24	94.22	85.19	11.369	106.51	23.92	4.62281
12/6/24	94.55	85.25	11.495	107.89	24.11	4.68125
12/13/24	94.83	86.57	11.603	108.97	24.16	4.69438
12/20/24	94.52	86.13	11.618	110.22	24.24	4.70656
12/27/24	94.50	86.07	11.620	110.02	24.18	4.71063
1/3/25	94.75	86.30	11.673	112.27	24.26	4.74375
1/10/25	95.92	87.83	11.790	114.12	27.72	4.78344
1/17/25	95.25	87.68	11.830	117.24	24.78	4.77219

	Belgium	France	Holland	Italy	Swit	U.S.
1/24/25	93.97	88.30	11.890	116.43	24.85	4.79875
1/31/25	92.24	87.77	11.900	114.94	24.84	4.79375
2/7/25	92.80	87.87	11.870	115.35	24.78	4.77344
2/14/25	95.14	90.60	11.870	116.28	24.79	4.77281
2/21/25	94.68	89.67	11.905	116.42	24.79	4.76313
2/28/25	94.77	91.37	11.933	117.75	24.80	4.75813
3/7/25	94.08	90.73	11.965	116.98	24.79	4.76750
3/14/25	94.64	92.00	12.010	117.85	24.83	4.78750
3/21/25	94.35	91.33	12.015	117.79	24.79	4.78000
3/28/25	93.22	89.80	12.018	116.98	24.80	4.77850
4/4/25	94.25	91.02	12.005	116.77	24.80	4.78250

Key: The 90-Day forward rates come from Einzig (1937) and represent end of the week quotations from the London exchange market. All rates are quoted vis a vis the pound.

Monthly Wholesale Prices

	Belgium	Britain	France	Germany	Holland	U.S.
1/29/21		246	415	143900	214	114.0
2/26/21		225	385	137600	198	104.9
3/26/21		211	367	133800	188	102.4
4/30/21		205	354	132600	177	98.9
5/28/21		202	337	130800	182	96.2
6/25/21		198	332	136600	183	93.4
7/30/21		194	337	142800	177	93.4
8/27/21	347	190	338	191700	180	93.5
9/24/21	368	187	351	206700	180	93.4
10/29/21	372	181	338	246000	170	94.1
11/26/21	374	173	339	341600	166	94.2
12/31/21	369	168	333	348700	166	92.9
1/28/22	366	164	320	366500	163	91.4
2/25/22	356	162	313	410300	165	92.9
3/25/22	350	160	314	543300	164	92.8
4/29/22	344	160	320	635500	163	93.2
5/27/22	348	160	323	645800	165	96.1
6/24/22	356	160	332	703000	165	96.3
7/29/22	360	160	332	1005900	164	99.4
8/26/22	360	156	338	1920000	156	98.6
9/30/22	364	154	336	2870000	152	99.3
10/28/22	385	155	344	5660000	155	99.6
11/25/22	408	157	360	11540000	158	100.5
12/30/22	407	156	370	14750000	155	100.7

	Belgium	Britain	France	Germany	Holland	U.S.
1/27/23	434	157	395	27850000	157	102.0
2/24/23	474	158	431	55850000	155	103.3
3/31/23	482	160	433	48880000	156	104.5
4/28/23	480	162	423	52120000	156	103.9
5/26/23	474	160	415	81700000	149	101.9
6/30/23	484	159	417	1.94e+08	149	100.3
7/28/23	504	157	415	7.48e+08	145	98.4
8/25/23	529	155	420	9.44e+09	142	97.8
9/29/23	514	158	433		145	99.7
10/27/23	515	158	429		148	99.4
11/24/23	531	161	452		153	98.4
12/29/23	545	163	468		154	98.1
1/26/24	580	165	505		156	99.6
2/23/24	642	167	555		158	99.7
3/29/24	625	165	510		155	98.5
4/26/24	555	165	459		154	97.3
5/31/24	557	164	468		153	95.9
6/28/24	565	163	475		151	94.9
7/26/24	566	163	491		151	95.6
8/30/24	547	165	487		151	97.0
9/27/24	550	167	496		158	97.1
10/25/24	555	170	508		161	98.2
11/29/24	569	170	514		161	99.1
12/27/24	566	170	518		160	101.5
1/31/25	559	171	525		160	102.9
2/28/25	551	169	526		158	104.0
3/28/25	546	166	524		155	104.2
4/25/25	538	162	523		151	101.9
5/30/25	537	159	531		151	101.6

Key: The monthly wholesale prices are the general wholesale price indices. The data come from Tinbergen (1934).

Monthly Retail Prices

	Belgium	Britain	France	Germany	Holland	U.S.
1/29/21	450	263	410	182300	205	119.2
2/26/21	434	249	392	166000	199	111.7
3/26/21	411	238	358	161500	194	110.1
4/30/21	399	232	328	156000	185	107.4
5/28/21	389	218	317	152300	191	103.1

	Belgium	Britain	France	Germany	Holland	U.S.
6/25/21	384	220	312	159500	192	100.7
7/30/21	379	226	306	172100	183	99.4
8/27/21	384	225	317	193500	192	98.7
9/24/21	386	210	329	264300	187	97.9
10/29/21	391	200	331	358500	173	97.8
11/26/21	394	195	326	566200	168	97.5
12/31/21	393	185	323	507100	168	95.3
1/28/22	387	179	319	507500	166	92.4
2/25/22	380	177	307	580000	169	92.6
3/25/22	371	173	294	746300	168	93.6
4/29/22	367	172	304	820300	168	94.3
5/27/22	365	170	317	861700	168	96.2
6/24/22	366	180	307	947900	167	97.5
7/29/22	366	175	292	1385400	163	97.9
8/26/22	366	172	289	324900	151	96.7
9/30/22	371	172	291	431100	144	98.0
10/28/22	376	176	290	903400	148	99.4
11/25/22	384	178	297	214100	154	99.7
12/30/22	384	175	305	243200	153	99.6
1/27/23	383	173	309	475800	154	100.1
2/24/23	397	171	316	879600	151	101.1
3/31/23	408	168	321	681600	149	102.4
4/28/23	409	162	320	746600	146	102.4
5/26/23	413	160	325	1306100	138	101.0
6/30/23	419	162	331	3116600	137	99.7
7/28/23	429	165	321	10024400	135	98.2
8/25/23	439	168	328	1.33e+08	132	97.2
9/29/23	453	172	339		136	98.3
10/27/23	458	173	349		142	97.8
11/24/23	463	176	355		148	96.5
12/29/23	470	175	365		152	96.2
1/26/24	480	177	376		153	98.2
2/23/24	495	176	384		158	98.3
3/29/24	510	167	392		154	97.3
4/26/24	498	163	380		151	95.9
5/31/24	485	160	378		150	95.2
6/28/24	492	162	370		149	94.5
7/26/24	493	164	360		149	94.1
8/30/24	498	166	366		151	95.5
9/27/24	503	172	374		161	95.5
10/25/24	513	179	383		166	95.9
11/29/24	520	180	396		166	96.8
12/27/24	521	178	404		164	99.0
1/31/25	521	176	408		161	99.1
2/28/25	517	176	410		159	100.4
3/28/25	511	170	415		154	100.9

	Belgium	Britain	France	Germany	Holland	U.S.
4/25/25	506	167	409		149	98.8
5/30/25	502	166	418		148	99.6

Key: The data come from Tinbergen (1934). The price indices for Belgium and France represent general retail prices. The German index represents home goods. The British and Dutch indices measure retail food prices. The United States index measures finished good prices.

Monthly Retail Prices League of Nations

	Britain	France	Germany	U.S.
1/29/21	263	410	1040	169
2/26/21	249	382	1107	155
3/26/21	238	358	1137	154
4/30/21	232	328	1107	149
5/28/21	218	317	1117	142
6/25/21	220	312	1147	141
7/30/21	226	306	1278	145
8/27/21	225	317	1324	152
9/24/21	210	329	1359	150
10/29/21	200	331	1357	150
11/26/21	195	326	1286	149
12/31/21	185	323	1198	147
1/28/22	179	319	1123	139
2/25/22	177	307	3020	139
3/25/22	173	294	3602	136
4/29/22	172	304	4356	136
5/27/22	170	317	4680	136
6/24/22	180	307	5119	138
7/29/22	175	297	6836	139
8/26/22	172	289	9746	136

	Britain	France	Germany	U.S.
9/30/22	172	291	15417	137
10/28/22	176	290	26623	140
11/25/22	178	297	54982	142
12/30/22	175	305	80702	144
1/27/23	173	309	136606	141
2/24/23	171	316	318300	139
3/31/23	168	321	332000	139
4/28/23	162	320	350000	140
5/26/23	160	325	462000	140
6/30/23	162	331	1935000	141
7/28/23	165	321	4651000	144
8/25/23	168	328	67049000	143
9/29/23	172	339		146
10/27/23	173	349		147
11/24/23	176	355		148
12/29/23	175	365		147
1/26/24	177	376		146
2/23/24	176	384		144
3/29/24	167	392		141
4/26/24	163	380		138
5/31/24	160	378		138
6/28/24	162	370		140
7/26/24	164	360		141
8/30/24	166	366		141
9/27/24	172	374		144
10/25/24	179	383		146
11/29/24	180	396		147
12/27/24	178	404		149
1/31/25	176	408		151
2/28/25	176	410		148
3/28/25	170	415		148

	Britain	France	Germany	U.S.
4/25/25	167	409		147
5/30/25	166	418		148

Key: The data come from the Monthly Bulletin of Statistics from the League of Nations. Each index measures the retail price of food.

Monthly Money Supply

	Belgium	Britain	France	Germany	Holland
1/29/21	22.71388	21.59623	22.08578	11.2921	20.80715
2/26/21	22.72407	21.56138	22.04048	11.2820	20.76277
3/26/21	22.71196	21.54128	21.98654	11.2923	20.75689
4/30/21	22.70330	21.54437	21.95115	11.2999	20.77738
5/28/21	22.70399	21.56440	21.97059	11.3081	20.78229
6/25/21	22.69651	21.57042	21.89513	11.3302	20.72766
7/30/21	22.68926	21.57853	22.02754	11.3595	20.75263
8/27/21	22.69498	21.56095	21.86972	11.3822	20.73687
9/24/21	22.68575	21.56613	21.79759	11.4278	20.73322
10/29/21	22.66832	21.57938	21.81418	11.4860	20.75940
11/26/21	22.66732	21.56224	21.80541	11.5563	20.75515
12/31/21	22.66014	21.59079	21.88015	11.6606	20.74610
1/28/22	22.66617	21.58700	21.77304	11.7255	20.75776
2/25/22	22.67587	21.57427	21.76177	11.7496	20.71301
3/25/22	22.68364	21.54040	21.70422	11.8103	20.69394
4/29/22	22.67445	21.53952	21.75467	11.8882	20.73500
5/27/22	22.68054	21.54305	21.73268	11.9611	20.75573
6/24/22	22.68505	21.54084	21.76988	12.0518	20.70092
7/29/22	22.67445	21.53108	21.75787	12.1636	20.72466
8/26/22	22.67288	21.51172	21.67222	12.3314	20.68888
9/30/22	22.70950	21.49522	21.69367	12.5776	20.69846
10/28/22	22.71251	21.50671	21.66600	12.9029	20.71614
11/25/22	22.71004	21.49522	21.66639	13.3224	20.70754
12/30/22	22.69261	21.50854	21.73632	13.8138	20.70030
1/27/23	22.68603	21.51626	21.70234	14.2951	20.71473
2/24/23	22.68772	21.47892	21.70834	14.7996	20.67145
3/31/23	22.69901	21.45803	21.64633	15.3070	20.66489
4/28/23	22.69554	21.46568	21.65700	15.6180	20.68536
5/26/23	22.71374	21.46616	21.67647	15.8392	20.66701
6/30/23	22.69457	21.48173	21.68185	16.3226	20.64617

	Belgium	Britain	France	Germany	Holland
7/28/23	22.70164	21.48360	21.64195	17.1346	22.97991
8/25/23	22.72136	21.47090	21.59121	18.9761	20.65937
9/29/23	22.74455	21.31216	21.61526		20.69661
10/27/23	22.74733	21.47232	21.62017		20.73371
11/24/23	22.75115	21.47421	21.69631		20.74140
12/29/23	22.76306	21.50305	21.76707		20.76143
1/26/24	22.78924	21.49615	21.76071		20.75370
2/23/24	22.79694	21.47327	21.76000		20.73123
3/29/24	22.80620	21.46091	22.03780		20.71604
4/26/24	22.80670	21.47043	21.79211		20.73104
5/31/24	22.79857	21.46948	21.71763		20.71876
6/28/24	22.79379	21.49799	21.68949		20.69167
7/26/24	22.79051	21.48641	21.69858		20.69641
8/30/24	22.79367	21.47657	21.63233		20.68317
9/27/24	22.79304	21.47090	21.52257		20.69969
10/25/24	22.78835	21.48267	21.62343		20.69208
11/29/24	22.79518	21.47421	21.62870		20.68192
12/27/24	22.80645	21.49430	21.62748		20.66691
1/31/25	22.80794	21.49152	21.65700		22.94919
2/28/25	22.78835	21.48314	21.62546		20.62001
3/28/25	22.78110	21.46330	21.66756		20.62422
4/25/25	22.78212	21.46853	21.62058		20.61857
5/30/25	22.76799	21.45803	21.62627		20.62201

Key: The data come from Tinbergen (1934). The money supplies for Belgium, France, Holland and Britain are the sum of notes in circulation and private bank deposits. The data are in logs.

Monthly Spot Exchange Rates

	Belgium	France	Germany	Holland	U.S.
1/29/21	51.83	54.37	221	11.40	3.860
2/26/21	51.80	54.98	241	11.35	3.870
3/26/21	53.20	56.58	247	11.37	3.920
4/30/21	51.22	51.19	262	11.27	3.960
5/28/21	46.70	46.70	242	11.24	3.895
6/25/21	46.86	46.74	271	11.33	3.730

	Belgium	France	Germany	Holland	U.S.
7/30/21	48.55	46.92	290	11.58	3.563
8/27/21	49.20	47.65	322	11.82	3.688
9/24/21	52.80	52.35	405	11.76	3.735
10/29/21	55.25	54.00	690	11.52	3.925
11/26/21	61.25	57.80	1175	11.18	3.985
12/31/21	54.50	51.88	770	11.40	4.215
1/28/22	54.10	51.80	847	11.56	4.250
2/25/22	51.62	49.30	975	11.50	4.398
3/25/22	52.12	48.50	1400	11.59	4.385
4/29/22	52.12	48.27	1206	11.60	4.423
5/27/22	52.87	48.87	1305	11.43	4.450
6/24/22	54.82	52.16	1500	11.48	4.403
7/29/22	57.25	54.17	2677	11.48	4.448
8/26/22	62.32	59.40	8500	11.44	4.473
9/30/22	61.56	57.77	7100	11.29	4.370
10/28/22	68.05	62.15	17950	11.43	4.463
11/25/22	67.90	62.97	31500	11.41	4.500
12/30/22	69.25	63.57	33200	11.71	4.635
1/27/23	81.35	72.25	125000	11.76	4.640
2/24/23	88.27	77.60	105000	11.89	4.715
3/31/23	81.75	70.40	101000	11.88	4.675
4/28/23	79.17	68.22	136000	11.86	4.635
5/26/23	81.45	69.87	251000	11.82	4.625
6/30/23	88.87	75.62	850000	11.68	4.573
7/28/23	94.95	77.90	4500000	11.63	4.585
8/25/23	100.07	80.35	21000000	11.58	4.555
9/29/23	87.25	74.17		11.57	4.553
10/27/23	88.05	75.92		11.56	4.500
11/24/23	93.92	80.87		11.46	4.365
12/29/23	96.77	84.82		11.38	4.338
1/26/24	104.25	94.25		11.40	4.228

	Belgium	France	Germany	Holland	U.S.
2/23/24	113.75	99.75		11.53	4.313
3/29/24	100.00	78.45		11.64	4.300
4/26/24	80.62	68.75		11.77	4.383
5/31/24	97.25	84.40		11.52	4.305
6/28/24	93.56	81.80		11.50	4.320
7/26/24	95.75	86.12		11.51	4.400
8/30/24	89.06	82.12		11.62	4.503
9/27/24	91.85	84.80		11.57	4.473
10/25/24	93.70	86.20		11.44	4.490
11/29/24	94.42	85.82		11.46	4.623
12/27/24	94.62	87.27		11.65	4.713
1/31/25	92.32	88.40		11.90	4.795
2/28/25	94.95	92.57		11.90	4.760
3/28/25	93.15	90.60		11.98	4.773
4/25/25	95.60	92.60		12.02	4.813
5/30/25	99.30	96.92		12.10	4.860

Key: The data are from Einzig (1937) and represent the weekly quotation nearest the end of the month from January 1921 through April 4 1925, except in the German case when the data is truncated in August 1923.

Monthly Forward Rates

	Belgium	France	Germany	Holland	U.S.
1/29/21	51.48	54.07	219	11.405	3.87750
2/26/21	51.43	54.68	239	11.345	3.88750
3/26/21	52.85	56.31	245	11.365	3.92500
4/30/21	50.99	51.04	260	11.260	3.96188
5/28/21	46.53	46.26	240	11.240	3.90375
6/25/21	48.73	46.66	270	11.330	3.73625
7/30/21	48.50	46.96	289	11.580	3.56750

	Belgium	France	Germany	Holland	U.S.
8/27/21	49.15	47.68	320	11.820	3.69125
9/24/21	52.75	52.36	405	11.760	3.73625
10/29/21	55.15	54.03	688	11.525	3.93000
11/26/21	61.19	57.82	1173	11.185	3.98000
12/31/21	54.40	51.89	768	11.415	4.21688
1/28/22	54.02	51.79	845	11.565	4.25063
2/25/22	51.57	49.30	973	11.503	4.39813
3/25/22	52.05	48.50	1400	11.605	4.38500
4/29/22	52.05	48.28	1206	11.620	4.42281
5/27/222	52.84	48.88	1305	11.453	4.45125
6/24/22	54.80	52.18	1501	11.493	4.40344
7/29/22	57.24	54.25	2687	11.500	4.45063
8/26/22	62.31	59.51	8650	11.460	4.47500
9/30/22	61.49	57.80	7400	11.300	4.37375
10/28/22	68.03	62.25	19950	11.440	4.46875
11/25/22	67.89	63.07	35500	11.420	4.51000
12/30/22	69.20	63.60	35200	11.720	4.64625
1/27/23	81.32	72.32	142000	11.768	4.65000
2/24/23	88.24	77.70	141000	11.898	4.72500
3/31/23	81.72	70.49	106000	11.880	4.68500
4/28/23	79.15	68.25	151000	11.868	4.64375
5/26/23	81.44	69.10	287000	11.830	4.63375
6/30/23	88.85	75.68	1020000	11.697	4.57875
7/28/23	94.90	77.94	6100000	11.640	4.58875
8/25/23	100.13	80.40	28000000	11.581	4.57719
9/29/23	87.29	74.20		11.573	4.55625
10/27/23	88.10	75.97		11.559	4.50438
11/24/23	93.99	80.87		11.470	4.37875
12/29/23	96.79	84.87		11.440	4.34250
1/26/24	104.23	94.52		11.428	4.23375
2/23/24	113.95	100.33		11.543	4.31625

	Belgium	France	Germany	Holland	U.S.
3/29/24	100.15	79.57		11.644	4.30063
4/26/24	80.64	68.95		11.781	4.38438
5/31/24	97.40	85.10		11.530	4.30625
6/28/24	93.63	82.10		11.510	4.31938
7/26/24	95.77	86.19		11.517	4.39375
8/30/24	89.10	82.19		11.625	4.49688
9/27/24	91.88	84.89		11.585	4.46688
10/25/24	93.74	86.33		11.463	4.48688
11/29/24	94.50	86.07		11.503	4.62219
12/27/24	94.66	87.74		11.668	4.71281
1/31/25	92.34	88.68		11.900	4.79563
2/28/25	95.03	93.05		11.881	4.76063
3/28/25	93.12	90.90		11.963	4.77938
4/25/25	95.56	93.13		12.013	4.80938
5/30/25	99.27	97.47		12.093	4.85625

Key: The data are from Einzig (1937) and represent the weekly quotation nearest the end of the month from January 1921 through April 4 1925, except in the German case when the data is truncated in August 1923.

LIST OF REFERENCES

Einzig, Paul (1937), The Theory of Forward Exchange, London; Macmillan and Company.

League of Nations, Monthly Bulletin of Statistics, 1921-1926.

Tinbergen, J. (1934), International Abstract of Economic Statistics 1919-1930, International Conference of Economic Time Series, London.

APPENDIX 2

APPENDIX 2

The Johansen Methodology

One method for investigating long-run equilibrium relationships is to use the concept of cointegration introduced by Granger (1986) and Engle and Granger (1987). Two or more variables can be individually nonstationary, but if a linear combination exists that is stationary, the variables are said to be cointegrated. In addition, the existence of cointegration implies Granger-causality in at least one direction.

The Engle and Granger (1987) two-step method involves estimating the "cointegrating" relationship and then subjecting the residuals from this regression to a test for unit roots. If the residual series are nonstationary, the variables in the relationship will have no tendency to move together. While Stock (1987) shows that the estimate of the cointegrating value is consistent, there are two potential problems that exist.

Banerjee et al (1986) point out the possibility of small sample bias in the cointegrating relationship. This is particularly relevant for the 1920s since the data sets analyzed in chapter three contain at most 53 observations.

Another drawback is that this method assumes that there exists only one cointegrating vector. The possibility certainly exists for a series of three or more variables to have more than one long-run equilibrium. The possibility of multiple vectors complicates the analysis since economic theory does not usually provide guidance as to the choice of the "correct" equilibrium relationship.

The procedure that is utilized in this study is based on work by Johansen (1988,1989) and Johansen and Juselius (1989). This methodology employs full information maximum likelihood estimation. It allows estimation of multiple cointegrating vectors as well as allowing tests based on the number of cointegrating vectors to be carried out. Finally, the tests have nonstandard limiting distributions that are well defined and invariant.

Consider the following p dimensional vector x_t, $x_t = (x_{1t}, \ldots x_{pt})'$. If this vector is generated by a vector autoregression, then

$$X_t = \sum_{s=1}^{k} \pi_s X_{t-s} + \epsilon_t \tag{1}$$

where π_s are matrices of coefficients and ϵ_t is independently and identically distributed as normal with zero mean and constant variance (i.e. i.i.d. $N(0, \Omega)$).

It is useful to rewrite the model in (1) as

$$\Delta X_t = \sum_{s=1}^{k-1} \Gamma_s \Delta X_{t-s} - \pi X_{tpk} + \epsilon_t \tag{2}$$

where

$$\pi = I - \pi_1 - \cdots - \pi_k$$

and

$$\Gamma_s = -I + \pi_1 + \cdots + \pi_s \qquad (s=1, \ldots , k-1)$$

Notice that (2) is the usual VAR in first differences except that it contains the lagged levels X_{t-k}. The coefficient matrix π on X_{t-k} contains information about the long-run behavior of the system.

The Granger Representation Theorem[1] contains three possible scenarios concerning the behavior of π. If the coefficient matrix has full rank (i.e. rank(π) = p), then each variable in this vector autoregression is individually integrated of order zero.[2] If π has full rank, then the concept of cointegration loses its meaning.

In the other extreme, if the rank of π is zero, then all the variables are individually nonstationary and no cointegration exists. Thus, the system does not have a long-run relationship.

---

[1] R. Engle and C. Granger , "Co-integration and Error Correction: Representation, Estimation and Testing," Econometrica 55 (1987): 255-256.

[2] A variable is said to be integrated of order d, I(d), if this variable attains stationarity after differencing d times.

For cointegration to exist, the rank of π must equal r, where r is less than p. If this is the case, there exists r cointegrating vectors. Furthermore, if cointegration exists, then $\pi = \alpha\beta'$ where β is a pxr matrix of cointegrating vectors and α is a pxr matrix of error-correction terms.

The test that is employed in chapters two and three is the "trace test" for the number of cointegrating vectors. The null hypothesis in this test is that there are at most r cointegrating vectors (the alternative hypothesis is that there are no cointegrating vectors). The test statistic is formed by solving an eigenvalue problem developed from three moment matrices of residuals from two auxiliary VARs that regress ΔX_t and X_{t-k} on ΔX_{t-s} (s=1, ... , k-1). The test statistic

$$-2\ln(Q) = -T \sum_{s=r+1}^{p} \ln(1-\hat{\lambda}_s)$$

where $\hat{\lambda}_s$ s=r+1, • • •, p are eigenvalues with $\hat{\lambda}_1 > \hat{\lambda}_2 > \cdots > \hat{\lambda}_p$, has a nonstandard limiting distribution. Critical values for the test statistic are tabulated in Table D.2 in Johansen and Juselius (1989).

LIST OF REFERENCES

Banerjee, A., J. Dolada, D. Hendry and George Smith (1986), " Exploring Equilibrium Relationships in Econometrics Through Static Models: Some Monte Carlo Evidence," Oxford Bulletin of Economics and Statistics, 48, 253-277.

Engle, R. and C.W.J. Granger (1987), "Co-integration and Error Correction: Representation, Estimation and Testing," Econometrica, 55, 251-276.

Granger, C,W.J. (1986), "Developments in the Study of Cointegrated Economic Variables," Oxford Bulletin of Economics and Statistics, 48, 213-228.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," Journal of Economic Dynamics and Control, 12, 231-254.

Johansen, S. (1989), "Estimation and Testing for Cointegration Vectors in Gaussian Vector Autoregressive Models," Institute of Mathematical Statistics, University of Copenhagen, Preprint 3.

Johansen, S. and K. Juselius (1989), "The Full Information Maximum Likelihood Procedure for Inference on Cointegration - with Applications," Institute of Mathematical Statistics, University of Copenhagen, Preprint 4.

Stock, J.H. (1987), "Asymptotic Properties of Least Squares Estimates of Cointegration Vectors," Econometrica, 55, 1035-1056.